

# CHAPTER

# 1

# Coulomb's Laws and Electric Field

## DPP 1.1

### Electric Charge

#### Subjective Type

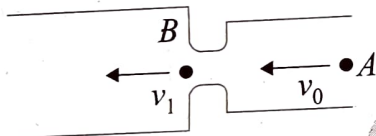
1. A glass rod rubbed with silk is brought close to two uncharged metallic spheres in contact with each other, inducing charges on them as shown in Figure (a) [given in the solution]. Discuss what happens when
- the spheres are slightly separated,
  - the glass rod is subsequently removed, and finally
  - the spheres are separated apart.

#### Single Correct Answer Type

2. A positively charged insulator is brought near (but does not touch) two metallic spheres that are in contact. The metallic spheres are then separated. The sphere which was initially farthest from the insulator will have:
- no net charge
  - a negative charge
  - a positive charge
  - either a negative or a positive charge.
3. Five balls numbered 1 to 5 are suspended using separate threads. Pairs (1, 2), (2, 4) and (4, 1) show electrostatic attraction, while pair (2, 3) and (4, 5) show repulsion. Therefore ball 1 must be
- positively charged
  - negatively charged
  - neutral
  - made of metal
4. There are two metallic spheres of same radii but one is solid and the other is hollow, then
- solid sphere can be given more charge
  - hollow sphere can be given more charge
  - they can be charged equally (maximum)
  - none of the above
5. When a body is earth connected, electrons from the earth flow into the body. This means the body is...
- uncharged
  - charged positively
  - charged negatively
  - an insulator
6. A positively charged rod is brought near to a non-conducting object. The rod is attracted to the object. From this observation we can't predict whether the object is charged or uncharged. Some additional experiments have been performed to identify whether the object is charged or uncharged, these experiments with their observations and conclusions drawn are given. Select the option in which conclusion drawn is correct.
- A negatively charged rod is brought near to object and the two attract, this shows that the object is neutral.
  - A negatively charged rod is brought near to object and two repel, this shows that the object is negatively charged.
  - A neutral rod is brought near to object and two attract, this shows that the object is negatively charged.
  - All of the above
7. A point charge  $+q$  is placed at a distance  $d$  from an isolated conducting plane. The field at a point  $P$  on the other side of the plane is
- directed perpendicular to the plane and away from the plane
  - directed perpendicular to the plane but towards the plane



- (c) directed radially away from the point charge  
(d) directed radially towards the point charge
8. In two cases, two identical conducting spheres are given equal charges, in one case of the same type whereas in another case of opposite type. The distance between the spheres is not large comparing with the diameter. Let  $F_1$  and  $F_2$  be the magnitude of the force of interaction between the spheres, as shown, then
- (a)  $F_1 > F_2$   
(b)  $F_1 = F_2$   
(c)  $F_1 < F_2$   
(d) information is not sufficient to draw the conclusion
9. The diagram shows the arrangement of three small uniformly charged spheres A, B and C. The arrows indicate the direction of the electrostatic forces acting between the spheres (for example, the left arrow on sphere A indicates the electrostatic force on sphere A due to sphere B). At least two of the spheres are positively charged. Which sphere, if any, could be negatively charged?
- (a) sphere A  
(b) sphere B  
(c) sphere C  
(d) no sphere
10. The velocity of an electron at point  $A_1$  is  $V_0$  where cross sectional area is  $A$ . The velocity of electron at the end of contraction at point B, where cross sectional area is  $2A$ , is  $V_1$ . Find the correct option:



- (a)  $V_1 < V_0$   
(b)  $V_1 = V_0$   
(c)  $V_1 > V_0$   
(d)  $V_1 = \frac{V_0}{2}$

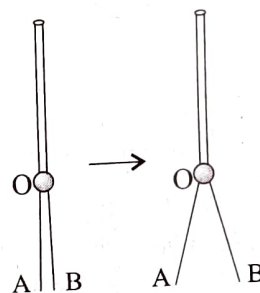
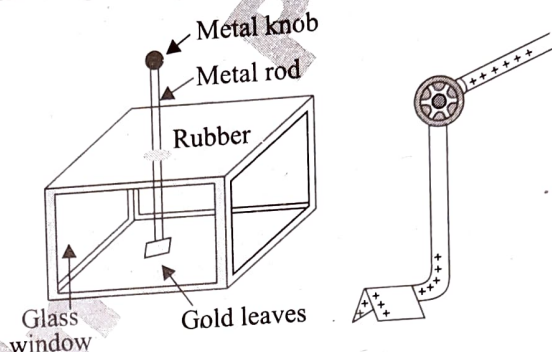
### Multiple Correct Answers Type

11. Select the correct statement (s) w.r.t. charges:
- (a) The additive property of charge is not an obvious property, but is related to the fact that charge is a scalar physical quantity.  
(b) Charge is invariant, i.e., its value is the same in different frames of reference having relative motion.  
(c) Charge is conserved for an electrically isolated system, this can be concluded from the scalar nature of charge.  
(d) Charge is conserved for an electrically isolated system, this can't be concluded from scalar nature of charge.
12. When a positively charged sphere is brought near a metallic sphere, it is observed that a force of attraction exists between the two. It means:
- (a) the metallic sphere is necessarily negatively charged  
(b) the metallic sphere may be electrically neutral

- (c) the metallic sphere may be negatively charged  
(d) nothing can be said about the charge of the metallic spheres

### Comprehension Type

A leaf electroscope is a simple apparatus to detect any charge on a body. It consists of two metal leaves  $OA$  and  $OB$ , free to rotate about  $O$ . Initially both are very slightly separated. When a charged object is touched to the metal knob at the top of the conducting rod, charge flows from knob to the leaves through the conducting rod. As the leaves are now charged similarly, they start repelling each other and get separated (deflected by certain angle).



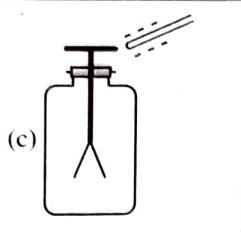
The angle of deflection in static equilibrium is an indicator of the amount of charge on the charged body.

13. When a  $+20\text{ C}$  rod is touched to the knob, the deflection of leaves was  $5^\circ$ , and when an identical rod of  $-40\text{ C}$  is touched, the deflection was found to be  $9^\circ$ . If an identical rod of  $+30\text{ C}$  is touched, then the deflection may be:
- (a)  $0$   
(b)  $2^\circ$   
(c)  $7^\circ$   
(d)  $11^\circ$
14. If we perform these steps one by one.

|                                                                            |     |
|----------------------------------------------------------------------------|-----|
| (i) A positively charged rod is brought closer to initially uncharged knob | (a) |
| (ii) Then the positively charged rod is touched to the knob                | (b) |



(iii) Now the +ve charged rod is removed, and a negatively charged rod is brought closer



In which case, the leaves will converge (come closer), as compared to the previous state?

- (a) (i)
- (b) (i) and (iii)
- (c) only (iii)
- (d) In all cases, the leaves will diverse

## Answers Key

### Single Correct Answer Type

2. (c)    3. (c)    4. (c)    5. (b)    6. (d)  
7. (a)    8. (c)    9. (a)    10. (c)

### Multiple Correct Answers Type

11. (a, b, d)    12. (b, c)

### Comprehension Type

13. (c)    14. (c)

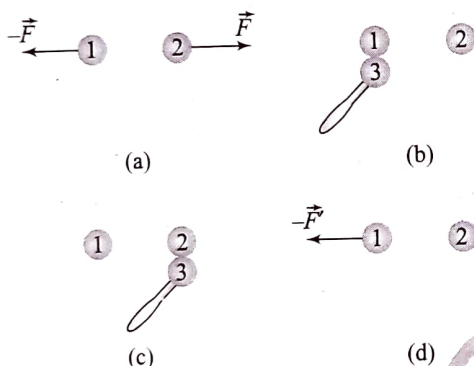


# DPP 1.2

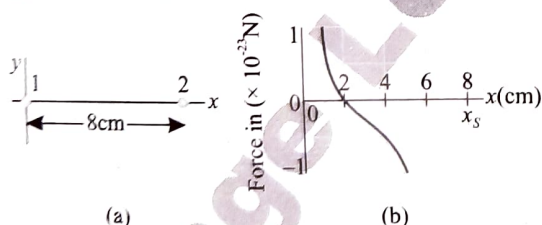
## Coulomb's Law 1

### Subjective Type

1. Identical isolated conducting spheres 1 and 2 have equal charges and are separated by a distance that is large compared with their diameters (Fig. a). The electrostatic force acting on sphere 2 due to sphere 1 is  $F$ . Suppose now that a third identical sphere 3, having an insulating handle and initially neutral, is touched first to sphere 1 (Fig. b), then to sphere 2 (Fig. c), and finally removed (Fig. d). The electrostatic force that now acts on sphere 2 has magnitude  $F'$ . What is the ratio  $\frac{F'}{F}$ ?



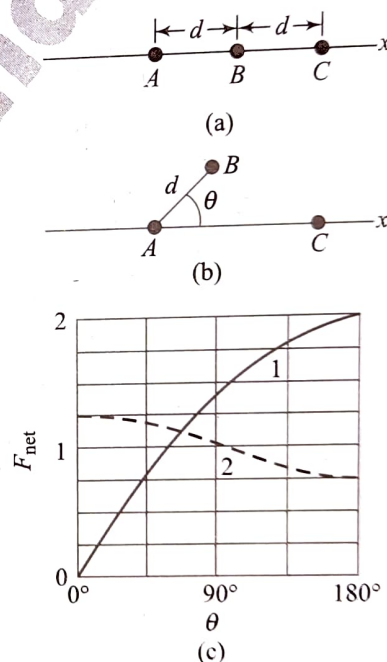
2. In Fig. a, particle 1 (of charge  $q_1$ ) and particle 2 (of charge  $q_2$ ) are fixed in place on an  $x$ -axis, 8.00 cm apart.



Particle 3 (of charge  $q_3 = +8.00 \times 10^{-19}$  C) is to be placed on the line between particles 1 and 2 so that they produce a net electrostatic force  $F_{\text{net}} = 2F_0$  on it. Figure b gives the  $x$  component of that force versus the coordinate  $x$  at which particle 3 is placed. The scale of the  $x$ -axis is set by  $x_s = 8.0$  cm. What are (a) the sign of charge  $q_1$  and (b) the ratio  $q_2/q_1$ ?

3. Figure (a) shows an arrangement of three charged particles separated by distance  $d$ . Particles A and C are fixed on the  $x$ -axis, but particle B can be moved along a circle centered on particle A. During the movement, a radial line between

A and B makes an angle  $\theta$  relative to the positive direction of the  $x$ -axis (Fig. b). The curves in Fig. c give, for two situations, the magnitude  $F_{\text{net}}$  of the net electrostatic force on particle A due to the other particles. That net force is given as a function of angle  $\theta$  and as a multiple of a basic amount  $F_0$ . For example on curve 1, at  $\theta = 180^\circ$  we see that  $F_{\text{net}} = 2F_0$ . (a) For the situation corresponding to curve 1, what is the ratio of the charge of particle C to that of particle B (including sign)? (b) For the situation corresponding to curve 2, what is that ratio?



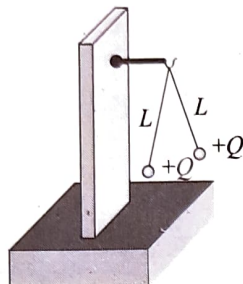
### Single Correct Answer Type

4. Two spherical conductors B and C having equal radii and carrying equal charges in them repel each other with a force  $F$  when kept apart at some distance. A third spherical conductor having the same radius as that of B but uncharged is brought in contact with B, then with C and finally removed away from both. The new force of repulsion between B and C is  
(a)  $F/4$  (b)  $3F/4$  (c)  $F/8$  (d)  $3F/8$
5. Two equally charged identical metal spheres A and B repel each other with a force ' $F$ '. The spheres are kept fixed with a distance ' $r$ ' between them. A third identical, but uncharged sphere C is brought in contact with A and then

placed at the mid-point of the line joining A and B. The magnitude of the net electric force on C is

- (a)  $F$  (b)  $3F/4$  (c)  $F/2$  (d)  $F/4$

6. Two small balls having equal positive charge  $Q$  (coulomb) on each are suspended by two insulated string of equal length  $L$  meter, from a hook fixed to a stand. The whole set-up is taken in satellite into space where there is no gravity (state of weightlessness). Then the angle between the string and tension in the string is



- (a)  $180^\circ, \frac{1}{4\pi\epsilon_0} \cdot \frac{Q^2}{(2L)^2}$  (b)  $90^\circ, \frac{1}{4\pi\epsilon_0} \cdot \frac{Q^2}{L^2}$   
 (c)  $180^\circ, \frac{1}{4\pi\epsilon_0} \cdot \frac{Q^2}{2L^2}$  (d)  $180^\circ, \frac{1}{4\pi\epsilon_0} \cdot \frac{QL}{4L^2}$

7. Two similar spheres having  $+Q$  and  $-Q$  charge are kept at a certain distance.  $F$  force acts between the two. If in the middle of two spheres, another similar sphere having  $+Q$  charge is kept, then it experiences a force in magnitude and direction as  
 (a) Zero having no direction  
 (b)  $8F$  towards  $+Q$  charge  
 (c)  $8F$  towards  $-Q$  charge  
 (d)  $4F$  towards  $+Q$  charge
8. Point charges  $+4q$ ,  $-q$  and  $+4q$  are kept on the  $x$ -axis at points  $x = 0$ ,  $x = a$  and  $x = 2a$  respectively, then  
 (a) Only  $q$  is in stable equilibrium  
 (b) None of the charges are in equilibrium  
 (c) All the charges are in unstable equilibrium  
 (d) All the charges are in stable equilibrium
9. Two identical balls having like charges and placed at a certain distance apart repel each other with a certain force. They are brought in contact and then moved apart to a distance equal to half their initial separation. The force of repulsion between them increases 4.5 times in comparison

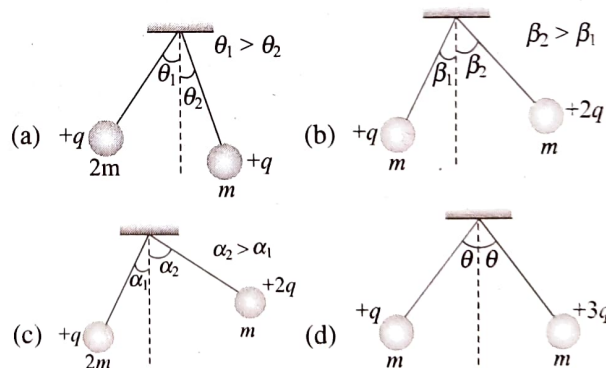
with the initial value. The ratio of the initial charges of the balls is

- (a) 2 (b) 3 (c) 4 (d) 6

10. Two charges  $+4e$  and  $+e$  are at a distance  $x$  apart. At what distance, a charge  $q$  must be placed from charge  $+e$  so that it is in equilibrium  
 (a)  $x/2$  (b)  $2x/3$  (c)  $x/3$  (d)  $x/6$
11. Charges  $4Q$ ,  $q$  and  $Q$  are placed along  $x$ -axis at positions  $x = 0$ ,  $x = l/2$  and  $x = l$ , respectively. Find the value of  $q$  so that force on charge  $Q$  is zero  
 (a)  $Q$  (b)  $Q/2$  (c)  $-Q/2$  (d)  $-Q$
12. Two equal negative charges  $-q$  are fixed at points  $(0, a)$  and  $(0, -a)$  on the  $y$ -axis. A positive charge  $Q$  is released from rest at the point  $(2a, 0)$  on the  $x$ -axis. The charge  $Q$  will  
 (a) execute simple harmonic motion about the origin  
 (b) move to the origin and remains at rest  
 (c) move to infinity  
 (d) execute oscillatory but not simple harmonic motion

### Multiple Correct Answers Type

13. Two free point charges  $+q$  and  $+4q$  are placed a distance  $x$  apart. A third charge is so placed that all the three charges are in equilibrium. Then  
 (a) unknown charge is  $-4q/9$   
 (b) unknown charge is  $-9q/4$   
 (c) it should be at  $(x/3)$  from smaller charge between them  
 (d) it should be placed at  $(2x/3)$  from smaller charge between them.
14. If two balls of given masses and charges are released, which of the following is the correct arrangement in equilibrium?



## Answers Key

### Subjective Type

1.  $\frac{F'}{F} = \frac{3}{8}$  2. (a) Positive (b) 9  
 3. (a)  $-4$  (b) 16

### Single Correct Answer Type

4. (d) 5. (a) 6. (a) 7. (c) 8. (c)  
 9. (a) 10. (c) 11. (d) 12. (d)

### Multiple Correct Answers Type

13. (a, c) 14. (a, c, d)

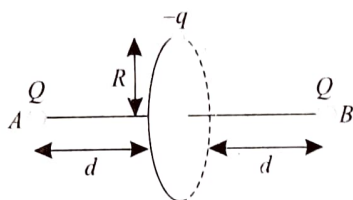


# DPP 1.3

## Coulomb's Law 2

### Subjective Type

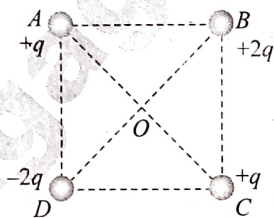
1. Two positive point charges each of magnitude  $10\text{ C}$  are fixed at positions  $A$  and  $B$  at a separation  $2d = 6\text{ m}$ . A negatively charged particle of mass  $m = 90\text{ gm}$  and charge of magnitude  $10 \times 10^{-6}\text{ C}$  is revolving in a circular path of radius  $4\text{ m}$  in the plane perpendicular to the line  $AB$  and bisecting the line  $AB$ . Neglect the effect of gravity. Find the angular velocity of the particle.



2. Four point positive charges are held at the vertices of a square in a horizontal plane. Their masses are  $1\text{ kg}$ ,  $2\text{ kg}$ ,  $3\text{ kg}$  and  $4\text{ kg}$ . Another point positive charge of mass  $10\text{ kg}$  is kept on the axis of the square. The weight of this fifth charge is balanced by the electrostatic force due to those four charges. If the four charges on the vertices are released such that they can freely move in any direction (vertical, horizontal, etc.). Find the acceleration of the centre of mass of the four charges immediately after the release. (Use  $g = 10\text{ m/s}^2$ )

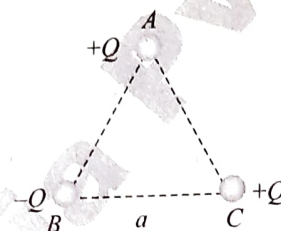
### Single Correct Answer Type

3. Four charges are arranged at the corners of a square  $ABCD$ , as shown in the adjoining figure. The force on the charge kept at the centre  $O$  is

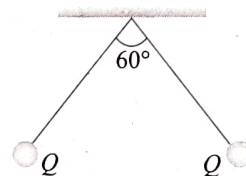


- (a) zero  
(b) along the diagonal  $AC$   
(c) along the diagonal  $BD$   
(d) perpendicular to side  $AB$
4. Three charges are placed at the vertices of an equilateral triangle of side ' $a$ ' as shown in the following figure. The

force experienced by the charge placed at the vertex  $A$  in a direction normal to  $BC$  is

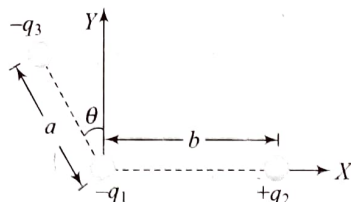


- (a)  $Q^2/(4\pi\epsilon_0 a^2)$  (b)  $-Q^2/(4\pi\epsilon_0 a^2)$   
(c) Zero (d)  $Q^2/(2\pi\epsilon_0 a^2)$
5. Two small spherical balls each carrying a charge  $Q = 10\text{ }\mu\text{C}$  ( $10\text{ micro-coulomb}$ ) are suspended by two insulating threads of equal lengths  $1\text{ m}$  each, from a point fixed in the ceiling. It is found that in equilibrium threads are separated by an angle  $60^\circ$  between them, as shown in the figure. What is the tension in the threads  
(Given:  $\frac{1}{(4\pi\epsilon_0)} = 9 \times 10^9\text{ Nm/C}^2$ )
- (a)  $18\text{ N}$  (b)  $1.8\text{ N}$   
(c)  $0.18\text{ N}$  (d) None of the above

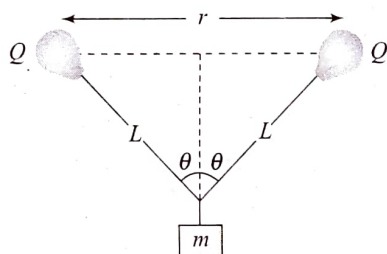


6. Equal charges  $Q$  are placed at the four corners  $A, B, C, D$  of a square of length  $a$ . The magnitude of the force on the charge at  $B$  will be
- (a)  $\frac{3Q^2}{4\pi\epsilon_0 a^2}$  (b)  $\frac{4Q^2}{4\pi\epsilon_0 a^2}$   
(c)  $\left(\frac{1+\sqrt{2}}{2}\right) \frac{Q^2}{4\pi\epsilon_0 a^2}$  (d)  $\left(2 + \frac{1}{\sqrt{2}}\right) \frac{Q^2}{4\pi\epsilon_0 a^2}$
7. Four charges equal to  $-Q$  are placed at the four corners of a square and a charge  $q$  is at its centre. If the system is in equilibrium the value of  $q$  is
- (a)  $-\frac{Q}{4}(1+2\sqrt{2})$  (b)  $\frac{Q}{4}(1+2\sqrt{2})$   
(c)  $-\frac{Q}{2}(1+2\sqrt{2})$  (d)  $\frac{Q}{2}(1+2\sqrt{2})$

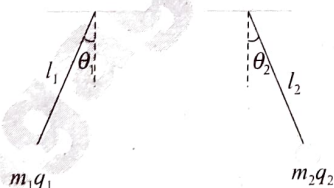
8. Three charges  $-q_1$ ,  $+q_2$  and  $-q_3$  are placed as shown in the figure. The x-component of the force on  $-q_1$  is proportional to



- (a)  $\frac{q_2}{b^2} - \frac{q_3}{a^2} \sin \theta$  (b)  $\frac{q_2}{b^2} - \frac{q_3}{a^2} \cos \theta$   
 (c)  $\frac{q_2}{b^2} + \frac{q_3}{a^2} \sin \theta$  (d)  $\frac{q_2}{b^2} + \frac{q_3}{a^2} \cos \theta$
9. Two similar balloons filled with helium gas are tied to  $L$  m long strings. A body of mass  $m$  is tied to another ends of the strings. The balloons float on air at distance  $r$ . If the amount of charge on the balloons is same then the magnitude of charge on each balloon will be

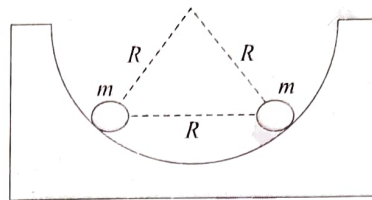


- (a)  $\left[ \frac{mgr^2}{2k} \tan \theta \right]^{1/2}$  (b)  $\left[ \frac{2k}{mgr^2} \tan \theta \right]^{1/2}$   
 (c)  $\left[ \frac{mgr}{2k} \cot \theta \right]^{1/2}$  (d)  $\left[ \frac{2k}{mgr} \tan \theta \right]^{1/2}$
10. Two small spheres with mass  $m_1$  and  $m_2$  hang from massless insulating threads of length  $l_1$  and  $l_2$ . The two spheres carry charges  $q_1$  and  $q_2$  respectively. The spheres are hung such that they are on the same horizontal level and the threads are inclined to the vertical at angles  $\theta_1$  and  $\theta_1$ . Which of the condition is required if  $\theta_1 = \theta_2$ ?

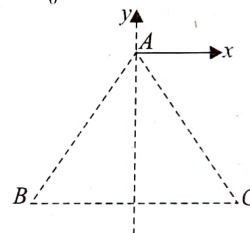


- (a) If  $m_1 = m_2$  (b)  $|q_1| = |q_2|$   
 (c)  $l_1 = l_2$  (d)  $\frac{q_1}{m_1} = \frac{q_2}{m_2}$
11. Two identical small balls each have a mass  $m$  and charge  $q$ . When placed in a hemispherical bowl of radius  $R$  with frictionless, nonconductive walls, the beads move, and

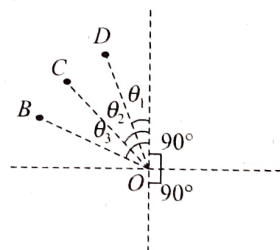
at equilibrium the line joining the balls is horizontal and the distance between them is  $R$  (see figure). Neglect any induced charge on the hemispherical bowl. Then the charge on each bead is: (here  $K = \frac{1}{4\pi\epsilon_0}$ )



- (a)  $q = R \left( \frac{mg}{K\sqrt{3}} \right)^{1/2}$  (b)  $q = \left( R \frac{mg}{K\sqrt{3}} \right)^{1/2}$   
 (c)  $q = R \left( \frac{\sqrt{3}mg}{K} \right)^{1/2}$  (d)  $q = \left( R \frac{\sqrt{3}mg}{K} \right)^{1/2}$
12. Three similar charges  $+q$  are placed on 3 corners of an equilateral triangle  $ABC$  of side  $a$ . How many minimum charges should be placed on a circle of radius  $a$  with the centre at  $A$  so that resultant force on the charge placed at the centre is  $\frac{q^2}{4\pi\epsilon_0 a^2}$  along x-axis?



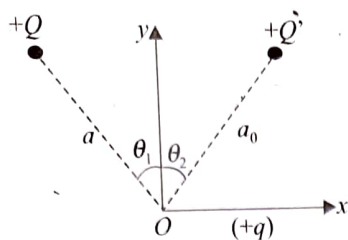
- (a) 4 (b) 6 (c) 3 (d) Any number
13. Four similar charges ( $+q$ ) are placed at origin  $O$ ,  $B$ ,  $C$  and  $D$  as shown. The angles are as shown. Charges at  $B$ ,  $C$  and  $D$  are equidistant from  $O$  at a distance of  $a$ . The forces of repulsion experienced by charge at  $O$  due to charges at  $B$  and  $D$  along  $CO$  are equal, given by  $\frac{q^2\sqrt{3}}{8\pi\epsilon_0 a^2}$ . Find the relation between  $\theta_1$ ,  $\theta_2$  and  $\theta_3$ :



- (a)  $\theta_3 - \theta_2 = \theta_1$  (b)  $2\theta_2 = \theta_1 + \theta_3$   
 (c)  $\theta_3 = 3(\theta_2 - \theta_1)$  (d) None of these
14. In the configuration, as shown,  $+q$  charge is placed at origin and charge  $Q$  and  $Q'$  are placed at distances  $a$  and  $a_0$  respectively from origin. If net electrostatic force on charge  $(+q)$  is along negative y-axis and  $\theta_1 = \theta_2/2$ , then  $(Q'/Q)$  is equal to:



## 1.8 Electrostatics and Current Electricity



(a)  $\frac{a_0^2}{a^2}$

(b)  $\frac{\pi a_0^2}{a^2}$

(c)  $\frac{\pi a_0^2}{4\sqrt{2}a^2}$

(d)  $\frac{\pi a_0^2}{6a^2}$

## Answers Key

### Subjective Type

1. 400 rad /s, No
2. 20 m/s<sup>2</sup> downwards

### Single Correct Answer Type

- |         |         |         |         |         |
|---------|---------|---------|---------|---------|
| 3. (c)  | 4. (c)  | 5. (b)  | 6. (c)  | 7. (b)  |
| 8. (c)  | 9. (a)  | 10. (a) | 11. (a) | 12. (c) |
| 13. (b) | 14. (d) |         |         |         |

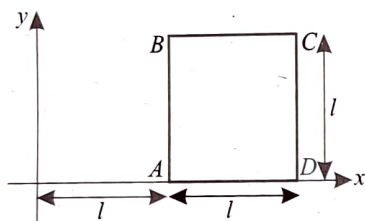
# DPP 1.4

## Electric Field 1

### Subjective Type

1. A square loop of side ' $l$ ' having uniform linear charge density ' $\lambda$ ' is placed in ' $xy$ ' plane as shown in the figure.

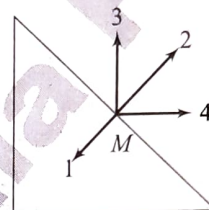
There is a non-uniform electric field  $\vec{E} = \frac{a}{l}(x+l)\hat{i}$  where  $a$  is a constant. Find the resultant electric force in  $\mu\text{N}$  on the loop if  $l = 10\text{ cm}$ ,  $a = 2\text{ N/C}$  and charge density  $\lambda = 2\text{ }\mu\text{C/m}$ .



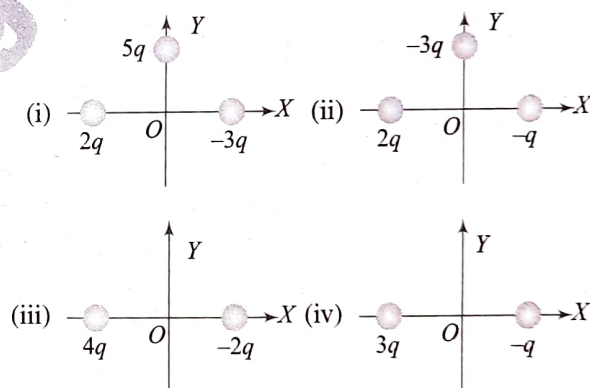
### Single Correct Answer Type

2. The insulation property of air breaks down at  $E = 3 \times 10^6$  volt/metre. The maximum charge that can be given to a sphere of diameter 5 m is approximately (in coulombs)
- (a)  $2 \times 10^{-2}$  (b)  $2 \times 10^{-3}$   
 (c)  $2 \times 10^{-4}$  (d)  $2 \times 10^{-5}$
3. Two point charges  $-q$  and  $+q/2$  are situated at the origin and at the point  $(a, 0, 0)$  respectively. The point along the  $x$ -axis where the electric field vanishes is
- (a)  $x = \frac{a}{\sqrt{2}}$  (b)  $x = \sqrt{2}a$   
 (c)  $x = \frac{\sqrt{2}a}{\sqrt{2}-1}$  (d)  $x = \frac{\sqrt{2}a}{\sqrt{2}+1}$
4. Two point charges  $+4q$  and  $+q$  are placed at a distance  $L$  apart. A third charge  $Q$  is so placed that all the three charges are in equilibrium. Then location and magnitude of third charge will be
- (a) At a distance  $\frac{L}{3}$  from  $+4q$  charge,  $\frac{4q}{9}$   
 (b) At a distance  $\frac{L}{3}$  from  $+4q$  charge,  $-\frac{4q}{9}$   
 (c) At a distance  $\frac{2L}{3}$  from  $+4q$  charge,  $-\frac{4q}{9}$   
 (d) At a distance  $\frac{2L}{3}$  from  $+q$  charge,  $\frac{4q}{9}$

5. Three identical point charges, as shown, are placed at the vertices of an isosceles right angled triangle. Which of the numbered vectors coincides in direction with the electric field at the mid-point  $M$  of the hypotenuse?



- (a) 1 (b) 2 (c) 3 (d) 4
6. In the following four situations charged particles are at equal distance from the origin. Arrange them according to the magnitude of the net electric field at origin greatest first



- (a) (i) > (ii) > (iii) > (iv)  
 (b) (ii) > (i) > (iii) > (iv)  
 (c) (i) > (iii) > (ii) > (iv)  
 (d) (iv) > (iii) > (ii) > (i)
7. Five point charges each having magnitude ' $q$ ' are placed at the corner of hexagon as shown in the figure. Net electric field at the centre ' $O$ ' is  $\vec{E}$ . To get net electric field at ' $O$ ' be  $6\vec{E}$ , charge placed on the remaining sixth corner should be

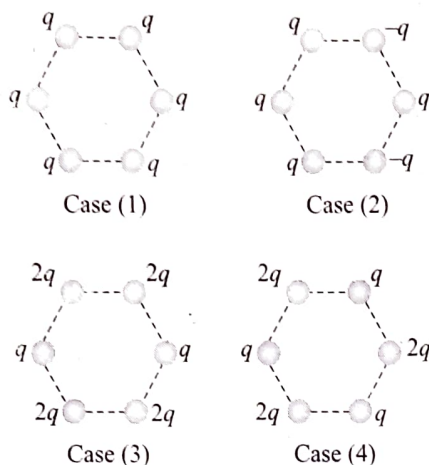


- (a)  $6q$  (b)  $-6q$  (c)  $5q$  (d)  $-5q$



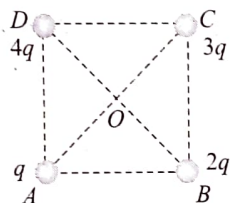
## 1.10 Electrostatics and Current Electricity

8. The following figures show regular hexagons, with charges at the vertices. In which of the following cases the electric field at the centre is not zero?



- (a) 1 (b) 2 (c) 3 (d) 4

9. Charges  $q$ ,  $2q$ ,  $3q$  and  $4q$  are placed at the corners A, B, C and D of a square as shown in the following figure. The direction of electric field at the centre of the square is along

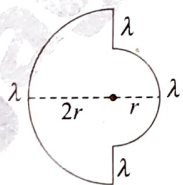


- (a) AB (b) CB (c) BD (d) AC

10. Infinite charges of magnitude  $q$  each are lying at  $x=1, 2, 4, 8, \dots$  meter on X-axis. The value of intensity of electric field at point  $x=0$  due to these charges will be

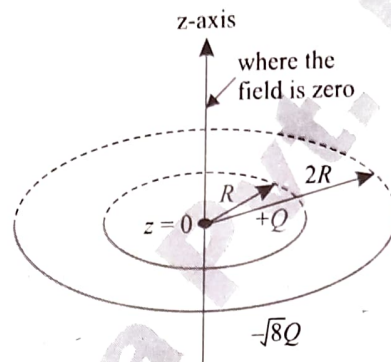
- (a)  $12 \times 10^9 q \text{ N/C}$  (b) Zero  
(c)  $6 \times 10^9 q \text{ N/C}$  (d)  $4 \times 10^9 q \text{ N/C}$

11. Two semicircular rings lying in the same plane of uniform linear charge density  $\lambda$  have radii  $r$  and  $2r$ . They are joined using two straight uniformly charged wires of linear charge density  $\lambda$  and length  $r$  as shown in the figure. The magnitude of electric field at common centre of semi-circular rings is



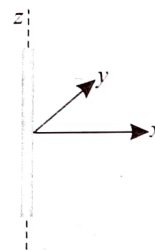
- (a)  $\frac{1}{4\pi\epsilon_0} \frac{3\lambda}{2r}$  (b)  $\frac{1}{4\pi\epsilon_0} \frac{\lambda}{2r}$   
(c)  $\frac{1}{4\pi\epsilon_0} \frac{2\lambda}{r}$  (d)  $\frac{1}{4\pi\epsilon_0} \frac{\lambda}{r}$

12. Two concentric rings, one of radius  $R$  and total charge  $+Q$  and the second of radius  $2R$  and total charge  $Q$ , lie in  $x$ - $y$  plane (i.e.,  $z=0$  plane). The common centre of rings lies at origin and the common axis coincides with  $z$ -axis. The charge is uniformly distributed on both rings. At what distance from origin is the net electric field on  $z$ -axis zero.



- (a)  $\frac{R}{2}$  (b)  $\frac{R}{\sqrt{2}}$  (c)  $\frac{R}{2\sqrt{2}}$  (d)  $\sqrt{2} R$

13. An infinitely long wire is kept along  $z$ -axis from  $z=-\infty$  to  $z=+\infty$ , having uniform linear charge density  $\frac{10}{9} \text{ nC/m}$ . The electric field at point (6 cm, 8 cm, 10 cm) will be



- (a)  $(120\hat{i} + 160\hat{j} + 200\hat{k}) \text{ V/m}$   
(b)  $200\hat{k} \text{ V/m}$   
(c)  $(160\hat{i} + 120\hat{j}) \text{ V/m}$   
(d)  $(120\hat{i} + 160\hat{j}) \text{ V/m}$

### Multiple Correct Answers Type

14. When two point charges  $q_A$  and  $q_B$  are placed at some separation on positive  $x$ -axis at points  $(x_A, 0)$  and  $(x_B, 0)$ . Given that  $|q_A| > |q_B|$  and  $x_B > x_A$ . If null point is the point where net electric field due to both the charges is zero, then
- (a) if both  $q_A$  and  $q_B$  are positive, null point lies at some point  $x_A < x < x_B$   
(b) if  $q_A$  is positive and  $q_B$  is negative, null point lies at some point  $x < x_A$   
(c) if  $q_A$  is positive and  $q_B$  is negative, null point lies at some point  $x > x_B$   
(d) if  $q_A$  is negative and  $q_B$  is positive, null point lies at some point  $x > x_B$

---

**Answers Key**

---

**Single Correct Answer Type**

- |         |         |        |         |         |
|---------|---------|--------|---------|---------|
| 2. (b)  | 3. (c)  | 4. (c) | 5. (b)  | 6. (c)  |
| 7. (d)  | 8. (b)  | 9. (b) | 10. (a) | 11. (d) |
| 12. (d) | 13. (d) |        |         |         |

**Multiple Correct Answers Type**

14. (a, c, d)

Cengage Learning India Pvt. Ltd.

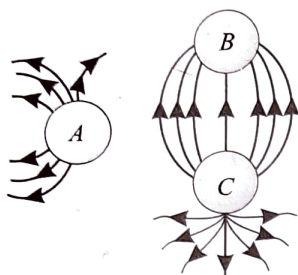


# DPP 1.5

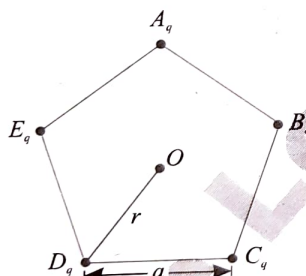
## Electric Field 2

### Subjective Type

1. Figure shows the electric field lines around three point charges  $A$ ,  $B$  and  $C$



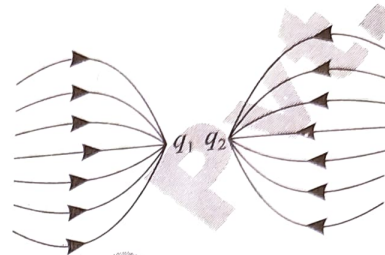
- Which charges are positive?
  - Which charge has the largest magnitude? Why?
  - In which region or regions of the picture could the electric field be zero? Justify your answer.
    - Near  $A$
    - Near  $B$
    - Near  $C$
    - Nowhere
2. Five charges,  $q$  each are placed at the corners of a regular pentagon of side.



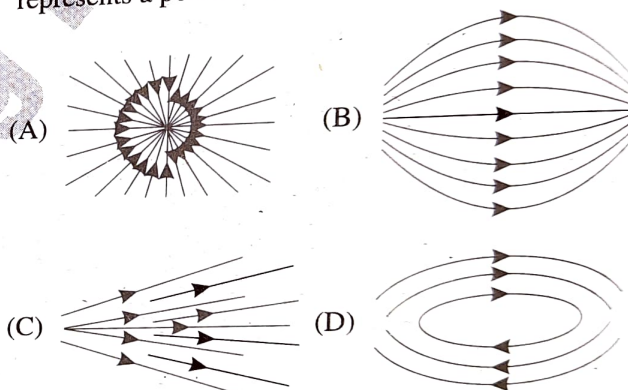
- What will be the electric field at  $O$ , the centre of the pentagon?
  - What will be the electric field at  $O$  if the charge from one of the corners (say  $A$ ) is removed?
  - What will be the electric field at  $O$  if the charge  $q$  at  $A$  is replaced by  $-q$ ?
- How would your answer to (a) be affected if pentagon is replaced by  $n$ -sided regular polygon with charge  $q$  at each of its corners?

### Single Answer Correct Type

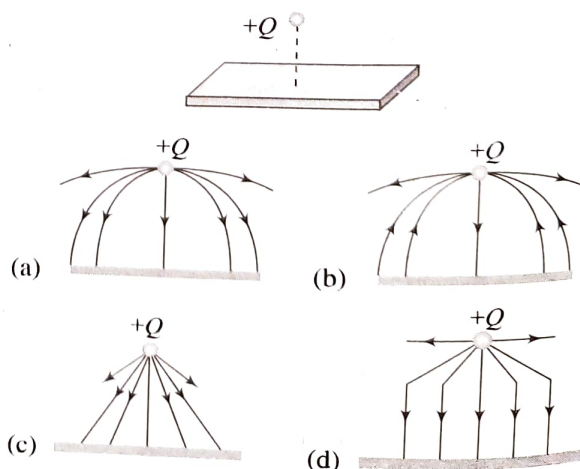
3. The given figure gives electric lines of force due to two charges  $q_1$  and  $q_2$ . What are the signs of the two charges?



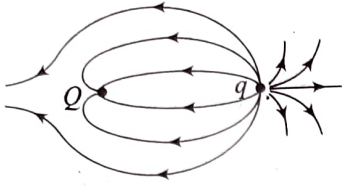
- Both are negative
  - Both are positive
  - $q_1$  is positive but  $q_2$  is negative
  - $q_1$  is negative but  $q_2$  is positive
4. Consider the four field patterns shown. Assuming there are no charges in the regions shown, which of the patterns represents a possible electrostatic field:



- $A$
  - $B$
  - $C$
  - $D$
5. A charge  $Q$  is fixed at a distance  $d$  in front of an infinite metal plate. The lines of force are represented by

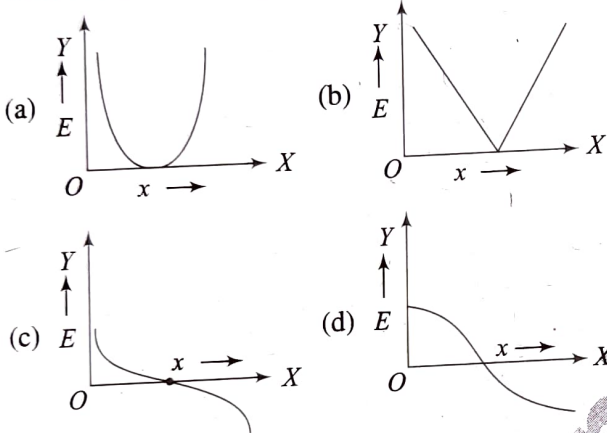


6. The lines of force of the electric field due to two charges  $q$  and  $Q$  are sketched in the figure. State if



- (a)  $Q$  is positive and  $|Q| > |q|$   
 (b)  $Q$  is negative and  $|Q| > |q|$   
 (c)  $q$  is positive and  $|Q| < |q|$   
 (d)  $q$  is negative and  $|Q| < |q|$

7. Two identical point charges are placed at a separation of  $d$ .  $P$  is a point on the line joining the charges, at a distance  $x$  from any one charge. The field at  $P$  is  $E$ ,  $E$  is plotted against  $x$  for values of  $x$  from close to zero to slightly less than  $d$ . Which of the following represents the resulting curve?



8. The bob of a pendulum of mass  $8 \mu\text{g}$  carries an electric charge of  $39.2 \times 10^{-10}$  coulomb in an electric field of  $20 \times 10^3$  volt/meter and it is at rest. The angle made by the pendulum with the vertical will be  
 (a)  $27^\circ$  (b)  $45^\circ$  (c)  $87^\circ$  (d)  $127^\circ$

9. Two charges each equal to  $\eta q (\eta^{-1} < \sqrt{3})$  are placed at the corners of an equilateral triangle of side  $a$ . The electric field at the third corner is  $E_3$  where ( $E_0 = q/4\pi\epsilon_0 a^2$ )  
 (a)  $E_3 = E_0$  (b)  $E_3 < E_0$   
 (c)  $E_3 > E_0$  (d)  $E_3 \geq E_0$

10. Two point charges  $(+Q)$  and  $(-2Q)$  are fixed on the  $X$ -axis at positions  $a$  and  $2a$  from origin respectively. At what positions on the axis, the resultant electric field is zero?

- (a) Only  $x = \sqrt{2}a$  (b) Only  $x = -\sqrt{2}a$   
 (c) Both  $x = \pm\sqrt{2}a$  (d)  $x = \frac{3a}{2}$  only

11. A hemisphere is uniformly charged positively. The electric field at a point on a diameter away from the centre is directed

- (a) perpendicular to the diameter  
 (b) parallel to the diameter  
 (c) at an angle tilted towards the diameter  
 (d) at an angle tilted away from the diameter

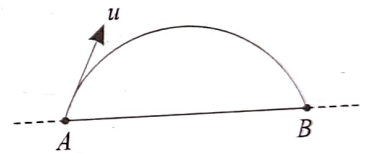
12. An electron falls through a small distance in a uniform electric field of magnitude  $2 \times 10^4 \text{ NC}^{-1}$ . The direction of the field is reversed keeping the magnitude unchanged and a proton falls through the same distance. The time of fall will be

- (a) same in both cases  
 (b) more in the case of an electron  
 (c) more in the case of proton  
 (d) independent of charge

13. There is a uniform electric field of strength  $10^3 \text{ V/m}$  along  $y$ -axis. A body of mass  $1 \text{ g}$  and charge  $10^{-6} \text{ C}$  is projected into the field from origin along the positive  $x$ -axis with a velocity  $10 \text{ m/s}$ . Its speed in  $\text{m/s}$  after  $10 \text{ s}$  is (neglect gravitation)

- (a) 10 (b)  $5\sqrt{2}$  (c)  $10\sqrt{2}$  (d) 20

14. In the figure shown there is a large sheet of charge of uniform surface charge density ' $\sigma$ '. A charge particle of



- charge ' $-q$ ' and mass ' $m$ ' is projected from a point A on the sheet with a speed ' $u$ ' with angle of projection such that it lands at maximum distance from A on the sheet. Neglecting gravity, find the time of flight.

- (a)  $\frac{2\sqrt{2}mv\epsilon_0}{\sigma q}$  (b)  $\frac{\sqrt{2}mv\epsilon_0}{5\sigma q}$   
 (c)  $\frac{mv\epsilon_0}{\sqrt{2}\sigma q}$  (d)  $\frac{mv\epsilon_0}{2\sqrt{2}\sigma q}$

## Answers Key

### Single Correct Answer Type

3. (a) 4. (b) 5. (a) 6. (c) 7. (d)

8. (b) 9. (c) 10. (b) 11. (a) 12. (c)  
 13. (c) 14. (a)

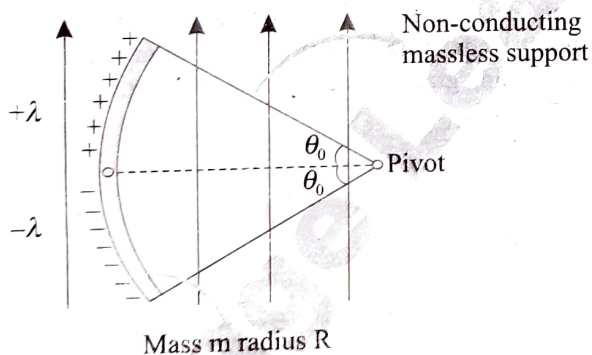


# DPP 1.6

## Electric Dipole

### Subjective Type

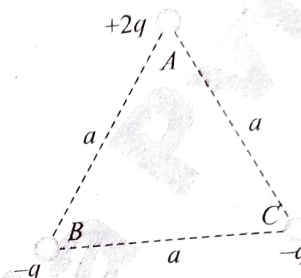
- In a certain region of space, electric field is along the  $z$ -direction throughout. The magnitude of electric field is, however, not constant but increases uniformly along the positive  $z$ -direction at the rate  $10^5 \text{ V/m}^2$ . What are the force and torque experienced by a system having a total dipole moment equal to  $10^{-7} \text{ Cm}$  in the negative  $z$ -direction?
- Electric dipole of moment  $\vec{P} = P\hat{i}$  is kept at a point  $(x, y)$  in an electric field  $\vec{E} = 4xy^2\hat{i} + 4x^2y\hat{j}$ . Find the magnitude of force acting on the dipole.
- A dipole with an electric moment  $p$  is located at a distance  $r$  from a long thread charged uniformly with a linear density  $\lambda$ . Find the force  $F$  acting on the dipole if the vector  $p$  is oriented
  - along the thread
  - along the radius vector  $r$
  - at the right angles to the thread and the radius vector  $r$ .
- Figure shows a charged rod, bent in the form of an arc of a circle. The charge distribution on the rod is shown in figure. The assembly is kept in a uniform electric field.



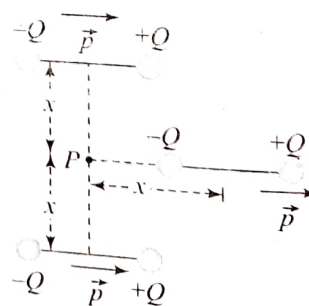
- Find the dipole moment of the rod.
- For small angular displacement the system find the time period of oscillation of the system.

### Single Correct Answer Type

- Three charges of  $(+2q)$ ,  $(-q)$  and  $(-q)$  are placed at the corners A, B and C of an equilateral triangle of side  $a$  as shown in the adjoining figure. Then the dipole moment of this combination is



- $qa$
  - Zero
  - $qa\sqrt{3}$
  - $\frac{2}{\sqrt{3}}qa$
- An electric dipole is placed along the  $x$ -axis at the origin O. A point P is at a distance of 20 cm from this origin such that OP makes an angle  $\frac{\pi}{3}$  with the  $x$ -axis. If the electric field at P makes an angle  $\theta$  with  $x$ -axis, the value of  $\theta$  would be
    - $\frac{\pi}{3}$
    - $\frac{\pi}{3} + \tan^{-1}\left(\frac{\sqrt{3}}{2}\right)$
    - $\frac{2\pi}{3}$
    - $\tan^{-1}\left(\frac{\sqrt{3}}{2}\right)$
  - An electric dipole is placed at the origin O and is directed along the  $x$ -axis. At a point P, far away from the dipole, the electric field is parallel to  $y$ -axis. OP makes an angle  $\theta$  with the  $x$ -axis then
    - $\tan \theta = \sqrt{3}$
    - $\tan \theta = \sqrt{2}$
    - $\theta = 45^\circ$
    - $\tan \theta = \frac{1}{\sqrt{2}}$
  - Three identical dipoles are arranged as shown in the figure. What will be the net electric field at P  $\left(k = \frac{1}{4\pi\epsilon_0}\right)$ ?



- $\frac{k \cdot p}{x^3}$
- $\frac{2kp}{x^3}$
- Zero
- $\frac{\sqrt{2}kp}{x^3}$



9. Two electric dipoles of moment  $P$  and  $64P$  are placed in opposite direction on a line at a distance of 25 cm. The electric field will be zero at point between the dipoles whose distance from the dipole of moment  $P$  is
- (a) 5 cm (b)  $\frac{25}{9}$  cm  
(c) 10 cm (d)  $\frac{4}{13}$  cm
10. Two point charges  $(+Q)$  and the  $(-2Q)$  are fixed on the X-axis at positions  $a$  and  $2a$  from origin respectively. At what positions on the axis, the resultant electric field is zero
- (a) Only  $x = \sqrt{2}a$  (b) Only  $x = -\sqrt{2}a$   
(c) Both  $x = \pm\sqrt{2}a$  (d)  $x = \frac{3a}{2}$  only
11. An electric dipole is kept on the axis of a uniformly charged ring at distance from the center of the ring. The direction of the dipole moment is along the axis. The dipole moment is  $P$ , charge of the ring is  $Q$  and radius of the ring is  $R$ . The force on the dipole is
- (a)  $\frac{4kPQ}{3\sqrt{3}R^2}$  (b)  $\frac{4kPQ}{3\sqrt{3}R^3}$   
(c)  $\frac{2kPQ}{3\sqrt{3}R^3}$  (d) zero
12. Two short dipoles  $p\hat{k}$  and  $\frac{p}{2}\hat{k}$  are located at  $(0,0,0)$  and  $(1\text{ m}, 0, 2\text{ m})$  respectively. The resultant electric field due to the two dipoles at the point  $(1\text{ m}, 0, 0)$  is
- (a)  $\frac{9P}{32\pi\epsilon_0}\hat{k}$  (b)  $\frac{-7P}{32\pi\epsilon_0}\hat{k}$   
(c)  $\frac{7P}{32\pi\epsilon_0}\hat{k}$  (d) none of these
13. Total electric force on an electric dipole placed in an electric field of a point charge is:
- (a) always zero  
(b) never zero  
(c) zero when mid-point of dipole coincides with the point charge  
(d) zero when dipole axis is along any electric line of force.
14. The locus of the points (in the  $xy$ -plane) where the electric field due to a dipole (dipole axis is along  $x$ -axis and its equatorial is along  $y$ -axis) is perpendicular to its axis is
- (a) straight line perpendicular to the axis  
(b) circle  
(c) parabola  
(d) straight line having inclination  $\theta = \tan^{-1}\sqrt{2}$  with the axis

## Answers Key

### Subjective Type

1. Force =  $10^{-2}$ ; Torque = 0

2.  $4py\sqrt{y^2 + 4x^2}$

3.  $F = 0$ ; (b)  $F = -\frac{\lambda p}{2\pi\epsilon_0 r^2}$ ; (c)  $F = \frac{\lambda p}{2\pi\epsilon_0 r^2}$

4. (a)  $4\lambda R^2 \sin^2 \theta_0$  (b)  $\pi \sqrt{\frac{m}{\lambda \sin^2 \theta_0 E}}$

### Single Correct Answer Type

5. (c) 6. (b) 7. (b) 8. (c) 9. (a)

10. (b) 11. (d) 12. (b) 13. (b) 14. (d)

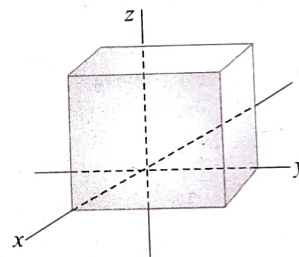
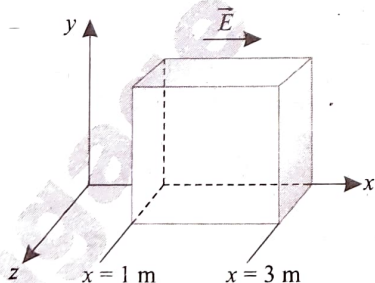
# Electric Flux and Gauss's Law

## DPP 2.1

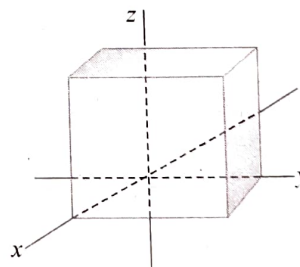
### Electric Flux

#### Subjective Type

1. A surface has the area vector  $\vec{A} = (2\hat{i} + 3\hat{j}) \text{ m}^2$ . What is the flux of a uniform electric field through the area if the field is (a)  $\vec{E} = 4\hat{i} \text{ N/C}$  and (b)  $\vec{E} = 4\hat{k} \text{ N/C}$ ?
2. An electric field given by  $\vec{E} = 4.0\hat{i} - 3.0(y^2 + 2.0)\hat{j}$  pierces a Gaussian cube of edge length 2.0 m and positioned as shown in the figure. (The magnitude  $E$  is in newtons per coulomb and the position  $x$  is in meters.) What is the electric flux through the (a) top face, (b) bottom face, (c) left face, and (d) back face? (e) What is the net electric flux through the cube?



4. At each point on the surface of the cube shown in the figure, the electric field is parallel to the  $z$ -axis. The length of each edge of the cube is 3.0 m. On the top face of the cube the field is  $\vec{E} = -34\hat{k} \text{ N/C}$ , and on the bottom face it is  $\vec{E} = +20\hat{k} \text{ N/C}$ . Find the net flux contained within the cube.



3. The cube in figure has edge length  $\sqrt{2} \text{ m}$  and is oriented as shown in a region of uniform electric field. Find the electric flux through the right face if the electric field, in newtons per coulomb, is given by (a)  $6.00\hat{i}$ , (b)  $-2.00\hat{j}$ , and (c)  $-3.00\hat{i} + 4.00\hat{k}$ . (d) What is the total flux through the cube for each field?

#### Single Correct Answer Type

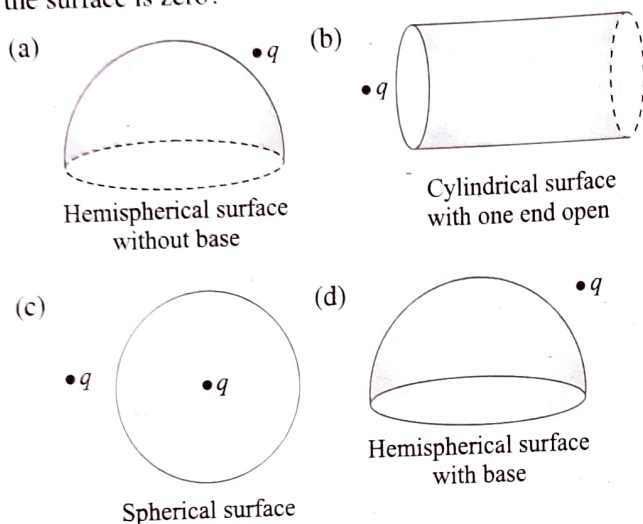
5. Electric flux through a surface of area  $10 \text{ m}^2$  lying in the  $xy$  plane is (if  $\vec{E} = \hat{i} + \sqrt{2}\hat{j} + \sqrt{3}\hat{k} \text{ N/C}$ )  
(a) 100 (b) 141.4 (c) 17.32 (d) 200



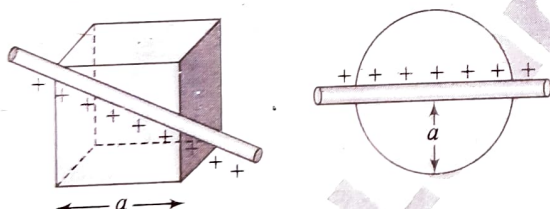
## 2.2 Electrostatics and Current Electricity

6. A cylinder of radius  $R$  and length  $L$  is placed in a uniform electric field  $E$  parallel to the cylinder axis. The total flux for the surface of the cylinder is given by
- (a)  $2\pi R^2 E$  (b)  $\pi R^2/E$   
 (c)  $(\pi R^2 - \pi R)/E$  (d) Zero

7. A point charge  $q$  is placed near hemispherical surface without base, cylindrical surface with one end open, spherical surface and hemispherical surface with base as shown in the figures in (a), (b), (c) and (d) respectively. In which of the following cases, the flux crossing through the surface is zero?

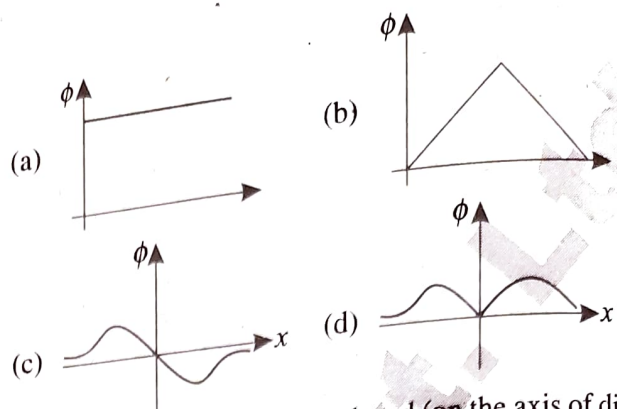
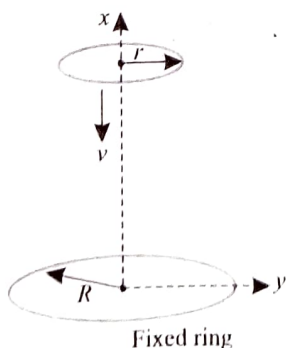


8. A linear charge having linear charge density  $\lambda$  penetrates a cube diagonally and then it penetrates a sphere diametrically as shown. What will be the ratio of flux coming out of cube and sphere?

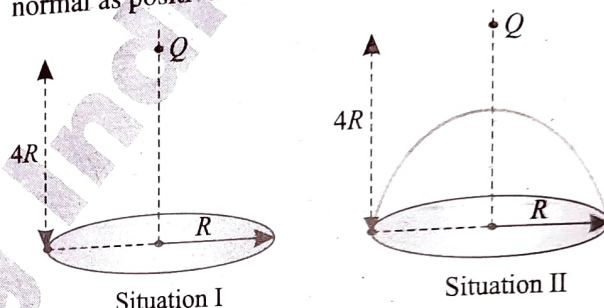


- (a)  $\frac{1}{2}$  (b)  $\frac{2}{\sqrt{3}}$   
 (c)  $\frac{\sqrt{3}}{2}$  (d)  $\frac{1}{1}$

9. A ring of radius  $R$  is placed in the plane with its centre at origin and its axis along the  $x$ -axis and having uniformly distributed positive charge. A ring of radius  $r (<< R)$  and coaxial with the larger ring is moving along the axis with constant velocity, then the variation of electrical flux ( $\phi$ ) passing through the smaller ring with position will be best represented by:

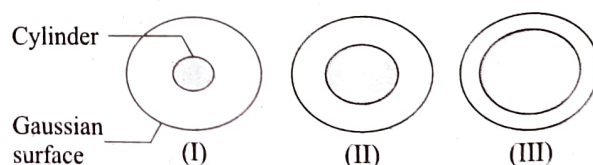


10. A positive point charge  $Q$  is placed (on the axis of disc) at a distance of  $4R$  above the centre of a disc of radius  $R$  as shown in situation I. The magnitude of electric flux through the disc is  $\phi$ . Now a hemispherical shell of radius  $R$  is placed over the disc such that it forms a closed surface as shown in situation II. The flux through the curved surface in situation II taking direction of area vector along outward normal as positive is



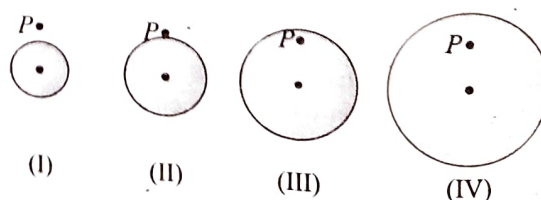
- (a) zero (b)  $\phi$  (c)  $-\phi$  (d)  $2\phi$

11. Figure shows, in cross section, three solid cylinders, each of length  $L$  and uniform charge  $Q$ . Concentric with each cylinder is a cylindrical Gaussian surface, with all three surfaces having the same radius. Rank the Gaussian surfaces according to the electric field at any point on the surface, greatest first.



- (a) I  $\rightarrow$  II  $\rightarrow$  III (b) II  $\rightarrow$  I  $\rightarrow$  III  
 (c) III  $\rightarrow$  II  $\rightarrow$  I (d) all tie

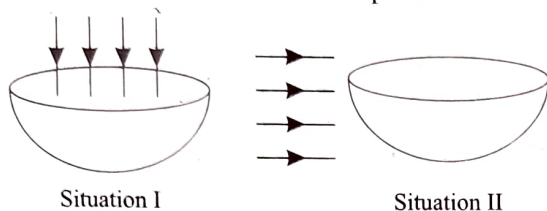
12. Figure shows four solid spheres, each with charge  $Q$  uniformly distributed through its volume. The figure also shows a point P for each sphere, all at the same distance from the center of the sphere. Rank the spheres according to the magnitude of the electric field they produce at point P.



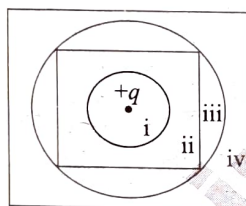
- (a) I and II tie  $\rightarrow$  III  $\rightarrow$  IV (b) II  $\rightarrow$  I  $\rightarrow$  III  $\rightarrow$  IV  
 (c) III  $\rightarrow$  II  $\rightarrow$  I  $\rightarrow$  IV (d) all tie

**Multiple Correct Answers Type**

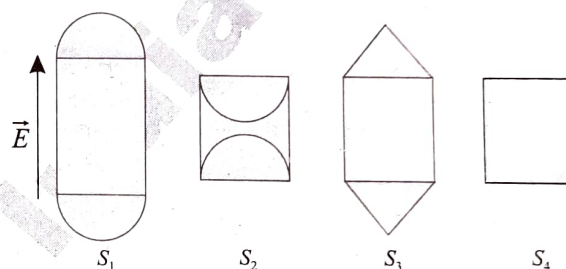
13. In the figure a hemispherical bowl of radius  $R$  is shown. Electric field of intensity  $E$  is present perpendicular to the circular cross section of the hemisphere.



- (a) The magnitude of electric flux through the hemispherical surface in situation I will be  $E\pi R^2$   
 (b) The magnitude of electric flux through the hemispherical surface in situation I will be  $2E\pi R^2$   
 (c) The magnitude of electric flux through the hemispherical surface in situation II will be  $\frac{E\pi R^2}{2}$   
 (d) The magnitude of electric flux through the hemispherical surface in situation II will be zero
14. Figure shows, in cross section, two Gaussian spheres and two Gaussian cubes that are centered on a positively charged particle. Rank greatest first, and indicate whether the magnitudes are uniform or variable along each surface.



- (a) net flux through all the four Gaussian surfaces will be equal  
 (b) the magnitudes of the electric fields on the surfaces (i) and (iii) will be constant  
 (c) the magnitudes of the electric fields on the surfaces (ii) and (iv) will be variable  
 (d) the magnitudes of the electric fields on all the surfaces will be constant
15. Figure shows four Gaussian surfaces consisting of identical cylindrical midsections but different end caps. The surfaces are in a uniform electric field that is directed parallel to the central axis of each cylindrical midsection. The end caps have these shapes:  $S_1$ , convex hemispheres;  $S_2$ , concave hemispheres;  $S_3$ , cones;  $S_4$ , flat disks. Rank the surfaces according to (a) the net electric flux through them and (b) the electric flux through the top end caps, greatest first.



- (a) net flux through all the four Gaussian surfaces will be equal  
 (b) the electric flux through the top end caps will be equal  
 (c) the electric flux through the top end cap  $S_1$  is greatest  
 (d) the electric flux through the top end cap  $S_3$  is greatest

**Answers Key****Subjective Type**

1. (a)  $8\text{ N} \cdot \text{m}^2/\text{C}$ ; (b) 0  
 2. (a)  $-72\text{ N} \cdot \text{m}^2/\text{C}$ , (b)  $+24\text{ N} \cdot \text{m}^2/\text{C}$  (c)  $-16\text{ N} \cdot \text{m}^2/\text{C}$  (d) zero (e)  $-48\text{ N} \cdot \text{m}^2/\text{C}$   
 3. (a) zero (b)  $-4.0\text{ N} \cdot \text{m}^2/\text{C}$  (c) zero (d) zero  
 4.  $-486\text{ N} \cdot \text{m}^2/\text{C}$

**Single Correct Answer Type**

5. (c) 6. (d) 7. (d) 8. (c) 9. (c)  
 10. (c) 11. (d) 12. (a)

**Multiple Correct Answers Type**

13. (b, d) 14. (a, b, c), 15. (a, b)

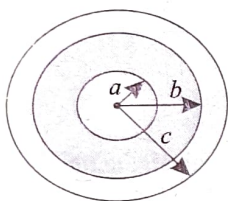


## DPP 2.2

## Electric Flux and Gauss Theorem

## Subjective Type

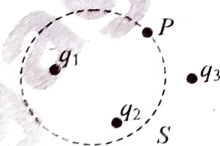
1. In figure, a solid sphere of radius  $a = 2.00$  cm is concentric with a spherical conducting shell of inner radius  $b = 2.00a$  and outer radius  $c = 2.40a$ . The sphere has a net uniform charge  $q_1 = +5.00$  C; the shell has a net charge  $q_2 = -q_1$ . What is the magnitude of the electric field at radial distances (a)  $r = 0$ , (b)  $r = a/2.00$ , (c)  $r = a$ , (d)  $r = 1.50a$ , (e)  $r = 2.30a$ , and (f)  $r = 3.50a$ ? What is the net charge on the (g) inner and (h) outer surface of the shell?



2. A uniform charge density of  $500 \text{ nC/m}^3$  is distributed throughout a spherical volume of radius  $6.00$  cm. Consider a cubical Gaussian surface with its center at the center of the sphere. What is the electric flux through this cubical surface if its edge length is (a)  $4.00$  cm and (b)  $14.0$  cm?
3. The net electric flux through each face of a die (singular of dice) has a magnitude in units of  $10^3 \text{ N.m}^2/\text{C}$  that is exactly equal to the number of spots  $N$  on the face (1 through 6). The flux is inward for  $N$  odd and outward for  $N$  even. What is the net charge inside the die?

## Single Correct Answer Type

4. A Gaussian surface  $S$  encloses two charges  $q_1 = q$  and  $q_2 = -q$ . The field at  $P$  is



- (a)  $\vec{E}_1 + \vec{E}_2$  (b)  $\vec{E}_1 + \vec{E}_2 + \vec{E}_3$   
(c)  $\vec{E}_3$  (d)  $\vec{E}_1 + \vec{E}_2 - \vec{E}_3$

Where  $\vec{E}_1$ ,  $\vec{E}_2$  and  $\vec{E}_3$  are the field contributed by  $q_1$ ,  $q_2$  and  $q_3$  at  $P$  respectively.

5. The electric field in a region is radially outward with magnitude  $E = A\gamma_0$ . The charge contained in a sphere of radius  $\gamma_0$  centered at the origin is

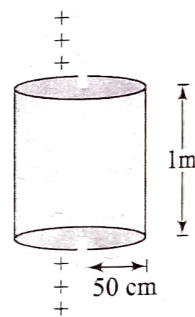
- (a)  $\frac{1}{4\pi\epsilon_0} A\gamma_0^3$  (b)  $4\pi\epsilon_0 A\gamma_0^3$   
(c)  $\frac{4\pi\epsilon_0 A}{\gamma_0}$  (d)  $\frac{1}{4\pi\epsilon_0} \frac{A}{\gamma_0^3}$

6. A charge  $q$  is placed at the centre of the open end of cylindrical vessel. The flux of the electric field through the surface of the vessel is

- (a) Zero (b)  $\frac{q}{\epsilon_0}$  (c)  $\frac{q}{2\epsilon_0}$  (d)  $\frac{2q}{\epsilon_0}$

7. Electric charge is uniformly distributed along a long straight wire of radius  $1$  mm. The charge per cm length of the wire is  $Q$  coulomb. Another cylindrical surface of radius  $50$  cm and length  $1$  m symmetrically encloses the wire as shown in the figure. The total electric flux passing through the cylindrical surface is

- (a)  $\frac{Q}{\epsilon_0}$  (b)  $\frac{100Q}{\epsilon_0}$   
(c)  $\frac{10Q}{(\pi\epsilon_0)}$  (d)  $\frac{100Q}{(\pi\epsilon_0)}$



8. In a region of space having a spherical symmetric distribution of charge, the electric flux enclosed by a concentric spherical Gaussian surface, varies with radius

$$r \text{ as } \phi = \begin{cases} \frac{\phi_0 r^2}{R^3}, & r \leq R \\ \phi_0, & r > R \end{cases} \text{ where } R \text{ and } \phi_0 \text{ are the constants.}$$

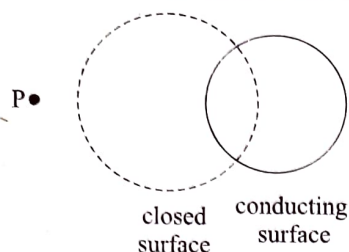
The electric field strength in the region is given as

- (a)  $E = \frac{\phi_0}{4\pi r^2}$ , for  $r \leq R$  (b)  $E = \frac{\phi_0}{4\pi r^2}$ , for  $r > R$   
(c)  $E = \frac{\phi_0 r}{4\pi R^3}$ , for  $r \leq R$  (d)  $E = \frac{\phi_0 r}{4\pi R^3}$ , for  $r > R$

9. In a region of space the electric field is in the  $x$ -direction and proportional to  $x$ , i.e.,  $\vec{E} = E_0 x \hat{i}$ . Consider an imaginary cubical volume of edge  $a$  with its edges parallel to the axes of coordinates. The charge inside this volume will be

- (a) zero (b)  $\epsilon_0 E_0 a^3$   
(c)  $\frac{1}{\epsilon_0} E_0 a^3$  (d)  $\frac{1}{6} \epsilon_0 E_0 a^3$

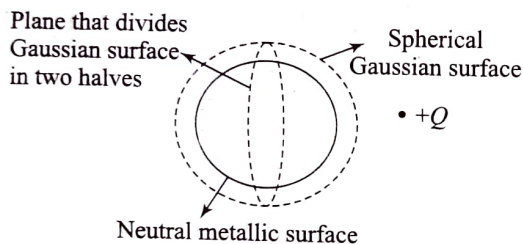
10. Figure shows a closed surface which intersects a conducting sphere. If a positive charge is placed at the point  $P$ , the flux of the electric field through the closed surface



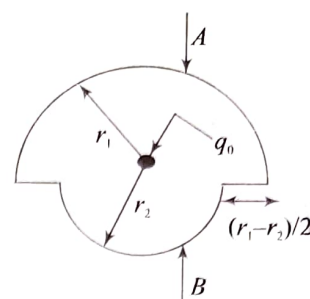
- (a) will remain zero (b) will become positive  
(c) will become negative (d) will become undefined

### Multiple Correct Answers Type

11. Figure shows a neutral metallic sphere with a point charge  $+Q$  placed near its surface. Electrostatic equilibrium conditions exist on metallic sphere. Mark the correct statements:



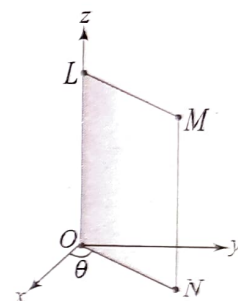
- (a) Net flux through Gaussian surface due to charge  $Q$  is zero  
(b) Net flux through Gaussian surface due to charges appearing on the outer surface of metallic sphere must be zero  
(c) If point charge  $Q$  is displaced a little towards metallic sphere, magnitude of net flux through right hemispherical closed Gaussian surface increases.  
(d) If point charge  $Q$  is displaced towards metallic sphere, charge distribution on outer surface of sphere will change
12.  $A$  and  $B$  are semi-spherical surfaces of radius  $r_1$  and  $r_2$  ( $r_1 > r_2$ ) with  $E_1$  and  $E_2$  as the electric fields at their surfaces. Charge  $q_0$  is placed as shown. What is the condition which may be satisfied?



- (a)  $\frac{\phi_1}{\phi_2} = 1$  (b)  $r_1^2 r_2^2 = E_1 E_2$   
(c)  $\frac{r_1}{\sqrt{E_2}} = \frac{r_2}{\sqrt{E_1}}$  (d)  $r_1 \sqrt{E_2} = r_2 \sqrt{E_1}$

### Comprehension Type

The electric field intensity at all points in space is given by  $\vec{E} = \sqrt{3}\hat{i} - \hat{j}$  volts/metre. A square frame  $LMNO$  of side 1 meter is shown in the figure. The point  $N$  lies in  $x$ - $y$  plane. The initial angle between line  $ON$  and  $x$ -axis is  $\theta = 60^\circ$ .



13. The magnitude of electric flux through area enclosed in square frame  $LMNO$  is  
(a) 0 volt/metre (b) 1 volt/metre (c) 2 volt/metre (d) 4 volt/metre
14. The work done by electric field in taking a point charge  $1\mu\text{C}$  from origin  $O$  to point  $M$  is  
(a)  $0\mu\text{J}$  (b)  $1\mu\text{J}$  (c)  $2\mu\text{J}$  (d)  $4\mu\text{J}$
15. The square frame  $LMNO$  is now rotated about  $z$ -axis by an angle  $30^\circ$ , such that  $\theta$  either increases or decreases. Then pick up the correct statement.  
(a) The magnitude of electric flux increases from initial value as  $\theta$  is increased.  
(b) The magnitude of electric flux increases from initial value as  $\theta$  is decreased.  
(c) The magnitude of electric flux may increase or decrease from initial value as  $\theta$  is changed.  
(d) The magnitude of electric flux will decrease from initial value as  $\theta$  is changed.

## Answers Key

### Subjective Type

1. (a) zero (b)  $5.6 \times 10^{13} \text{ N/C}$  (c)  $1.1 \times 10^{14} \text{ N/C}$   
(d)  $5 \times 10^{13} \text{ N/C}$  (e) zero (f) zero (g)  $-5.00 \text{ C}$   
(h) zero
2. (a)  $3.62 \text{ N.m}^2/\text{C}$  (b)  $51.1 \text{ N.m}^2/\text{C}$
3.  $2.66 \times 10^{-8} \text{ C}$

### Single Correct Answer Type

4. (b) 5. (b) 6. (c) 7. (b) 8. (b)  
9. (b) 10. (c)

### Multiple Correct Answers Type

11. (a, b, c, d) 12. (a, c)

### Comprehension Type

13. (c) 14. (d) 15. (a)

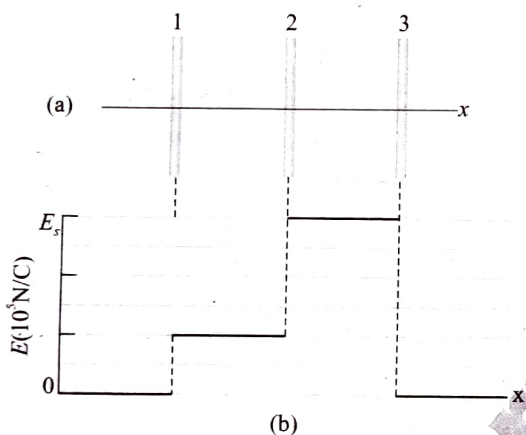


# DPP 2.3

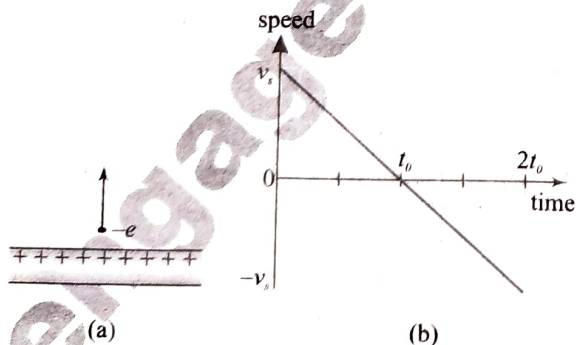
## Application of Gauss Theorem

### Subjective Type

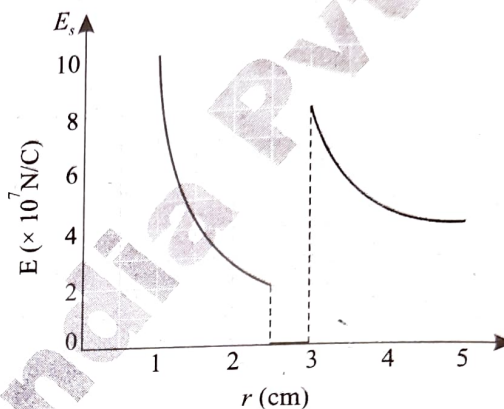
1. Figure (a) shows three plastic sheets that are large, parallel, and uniformly charged. Figure (b) gives the component of the net electric field along an  $x$ -axis through the sheets. The scale of the vertical axis is set by  $E_s = 6.0 \times 10^5 \text{ N/C}$ . What is the ratio of the charge density on sheet 3 to that on sheet 2?



2. In Fig (a), an electron is shot directly away from a uniformly charged plastic sheet, at speed  $v_s$ . The sheet is nonconducting, flat, and very large. Figure (b) gives the electron's vertical velocity component versus time  $t$  until the return to the launch point. What is the sheet's surface charge density?

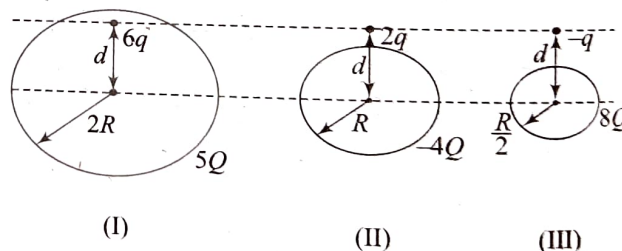


3. A charged particle is held at the center of a spherical shell. The following figure gives the magnitude  $E$  of the electric field versus radial distance  $r$ . What is the net charge on the shell?



### Single Correct Answer Type

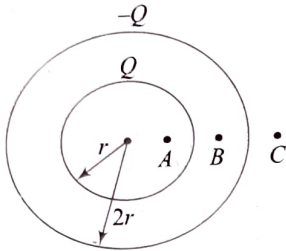
4. Figure, shown above, shows three situations involving a charged particle and a uniformly charged spherical shell. The charges and radii of the shells are indicated in the figure. If  $F_1$ ,  $F_2$  and  $F_3$  are the magnitudes of the forces on the particle due to the presence of the shell in situations (I), (II) and (III) respectively, then



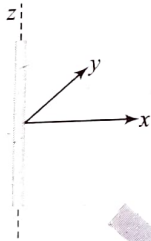
- (a)  $F_3 > F_2 > F_1$  (b)  $F_1 > F_2 = F_3$   
 (c)  $F_3 = F_2 > F_1$  (d)  $F_1 > F_2 > F_3$
5. There are three concentric thin spheres of radius  $a$ ,  $b$  and  $c$  ( $a > b > c$ ). The total surface charge densities on their surfaces are  $\sigma$ ,  $-\sigma$  and  $\sigma$  respectively. The magnitude of electric field at  $r$  (distance from centre) such that  $a > r > b$  is:
- (a) 0 (b)  $\frac{\sigma}{\epsilon_0 r^2} (b^2 - c^2)$   
 (c)  $\frac{\sigma}{\epsilon_0 r^2} (a^2 + b^2)$  (d) none of these
6. The electric field inside a sphere which carries a charge density proportional to the distance from the origin  $\rho = \alpha r$  ( $\alpha$  is a constant) is:

- (a)  $\frac{\alpha r^3}{4\epsilon_0}$  (b)  $\frac{\alpha r^2}{4\epsilon_0}$   
 (c)  $\frac{\alpha r^2}{3\epsilon_0}$  (d) none of these

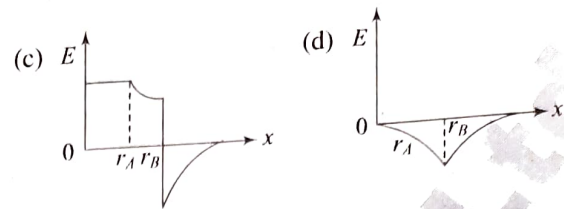
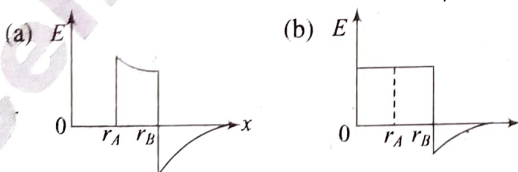
7. Consider two thin uniformly charged concentric shells of radii  $r$  and  $2r$  having charges  $Q$  and  $-Q$  respectively, as shown. Three points A, B and C are marked at distances  $\frac{r}{2}$ ,  $\frac{3r}{2}$  and  $\frac{5r}{2}$  respectively from their common centre. If  $E_A$ ,  $E_B$  and  $E_C$  are magnitudes of the electric fields at points A, B and C respectively, then



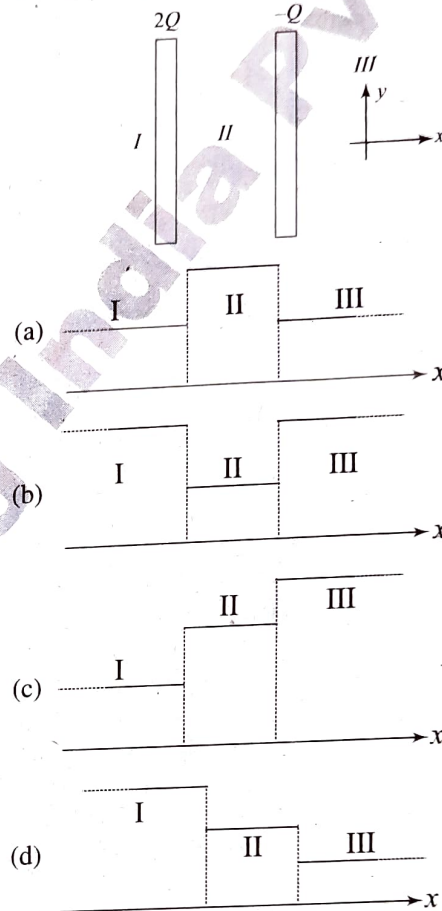
- (a)  $E_A > E_B > E_C$  (b)  $E_C > E_B > E_A$   
 (c)  $E_B > E_A = E_C$  (d)  $E_B > E_A > E_C$
8. An infinitely long wire is kept along  $z$ -axis from  $z = -\infty$  to  $z = +\infty$ , having uniform linear charge density  $\frac{10}{9} \text{ nC/m}$ . The electric field at point (6 cm, 8 cm, 10 cm) will be



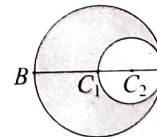
- (a)  $(120\hat{i} + 160\hat{j} + 200\hat{k}) \text{ V/m}$   
 (b)  $200\hat{k} \text{ V/m}$   
 (c)  $(160\hat{i} + 120\hat{j}) \text{ V/m}$   
 (d)  $(120\hat{i} + 160\hat{j}) \text{ V/m}$
9. Two concentric conducting thin spherical shells A and B having radii  $r_A$  and  $r_B$  ( $r_B > r_A$ ) are charged to  $Q_A$  and  $-Q_B$  ( $|Q_B| > |Q_A|$ ). The electrical field along a line (passing through the centre) is



10. Two large conducting thin plates are placed parallel to each other. They carry the charges as shown. The variation of magnitude of electric field in space due to this system is best given by



11. A positively charged sphere of radius  $r_0$  carries a volume charge density  $\rho$  (see figure). A spherical cavity of radius  $r_0/2$  is then scooped out and left empty, as shown.  $C_1$  is the centre of sphere and  $C_2$  that of cavity. What is the direction and magnitude of the electric field at point B?



- (a)  $\frac{17\rho r_0}{54\epsilon_0}$  left (b)  $\frac{\rho r_0}{6\epsilon_0}$  left  
 (c)  $\frac{17\rho r_0}{54\epsilon_0}$  right (d)  $\frac{\rho r_0}{6\epsilon_0}$  right

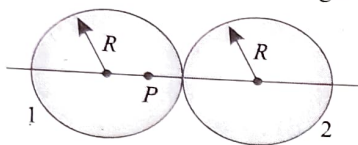


## 2.8 Electrostatics and Current Electricity

12. A charge  $q$  is placed at some distance along the axis of a uniformly charged disc of surface charge density  $\sigma$ . The flux due to the charge  $q$  through the disc is  $\phi$ . The electric force on charge  $q$  exerted by the disc is

- (a)  $\sigma\phi$  (b)  $\frac{\sigma\phi}{4\pi}$  (c)  $\frac{\sigma\phi}{2\pi}$  (d)  $\frac{\sigma\phi}{3\pi}$

13. Figure shows, in cross section, two solid spheres with uniformly distributed charge throughout their volumes. Each has radius  $R$ . Point  $P$  lies on a line connecting the centers of the spheres, at radial distance  $R/2.00$  from the center of sphere 1. If the net electric field at point  $P$  is zero, what is the ratio  $q_2/q_1$  of the total charges?



- (a)  $\frac{9}{8}$  (b)  $\frac{6}{5}$  (c)  $\frac{2}{5}$  (d)  $\frac{8}{9}$

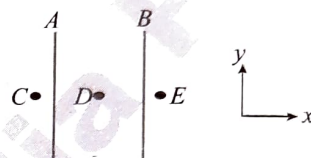
14. A very long uniformly charged circular cylinder (radius  $R$ ) has a surface charge density  $\sigma$ . A very long uniformly

charged line charge (linear charge density  $\lambda$ ) is placed along the cylinder axis. If electric field intensity vector outside the cylinder is zero, then:

- (a)  $\lambda = R\sigma$  (b)  $\lambda = -R\sigma$   
(c)  $\lambda = 2\pi R\sigma$  (d)  $\lambda = -2\pi R\sigma$

### Multiple Correct Answers Type

15. Two infinite plane sheets  $A$  and  $B$  are shown in the figure. The surface charge densities on  $A$  and  $B$  are  $(2/\pi) \times 10^{-9} \text{ C/m}^2$  and  $(-1/\pi) \times 10^{-9} \text{ C/m}^2$  respectively.  $C$ ,  $D$ ,  $E$  are three points where electric fields (in  $\text{N/C}$ ) are  $E_C$ ,  $E_D$  and  $E_E$  respectively.



- (a)  $\vec{E}_C = 18\hat{i}$  (b)  $\vec{E}_D = 54\hat{i}$   
(c)  $\vec{E}_D = 18\hat{i}$  (d)  $\vec{E}_E = 18\hat{i}$

## Answers Key

### Subjective Type

1. 1.5  
2.  $\frac{2\varepsilon_0 mv_s}{et_0}$   
3.  $6.6 \times 10^{-6} \text{ C}$

### Single Correct Answer Type

4. (c) 5. (b) 6. (a) 7. (c) 8. (d)  
9. (a) 10. (a) 11. (a) 12. (a) 13. (a)  
14. (d)

### Multiple Correct Answers Type

15. (b, d)

# CHAPTER

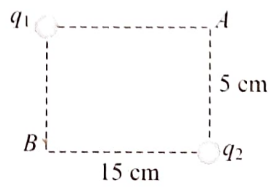
# 3

# Electric Potential

## DPP 3.1

### Work Done in Electric Field and Electric Potential

#### Single Correct Answer Type

- There is an electric field  $E$  in  $X$ -direction. If the work done on moving a charge  $0.2\text{ C}$  through a distance of  $2\text{ m}$  along a line making an angle  $60^\circ$  with the  $X$ -axis is  $4.0$ , what is the value of  $E$ 
  - $\sqrt{3}\text{ N/C}$
  - $4\text{ N/C}$
  - $5\text{ N/C}$
  - None of these
- Four equal charges  $Q$  are placed at the four corners of a square of each side is ' $a$ '. Work done in removing a charge  $-Q$  from its centre to infinity is
  - $0$
  - $\frac{\sqrt{2}Q^2}{4\pi\epsilon_0 a}$
  - $\frac{\sqrt{2}Q^2}{\pi\epsilon_0 a}$
  - $\frac{Q^2}{2\pi\epsilon_0 a}$
- Charges of  $+\frac{10}{3} \times 10^{-9}\text{ C}$  are placed at each of the four corners of a square of side  $8\text{ cm}$ . The potential at the intersection of the diagonals is
  - $150\sqrt{2}\text{ volt}$
  - $1500\sqrt{2}\text{ volt}$
  - $900\sqrt{2}\text{ volt}$
  - $900\text{ volt}$
- Three charges  $2q$ ,  $-q$  and  $-q$  are located at the vertices of an equilateral triangle. At the centre of the triangle,
  - the field is zero but potential is non-zero
  - the field is non-zero but potential is zero
  - both field and potential are zero
  - both field and potential are non-zero
- Two electric charges  $12\text{ }\mu\text{C}$  and  $-6\text{ }\mu\text{C}$  are placed  $20\text{ cm}$  apart in air. There will be a point  $P$  on the line joining these charges and outside the region between them, at which the electric potential is zero. The distance of  $P$  from  $-6\text{ }\mu\text{C}$  charge is
  - $0.10\text{ m}$
  - $0.15\text{ m}$
  - $0.20\text{ m}$
  - $0.25\text{ m}$
- A spherical conductor of radius  $2\text{ m}$  is charged to a potential of  $120\text{ V}$ . It is now placed inside another hollow spherical conductor of radius  $6\text{ m}$ . Calculate the potential to which the bigger sphere would be raised
  - $20\text{ V}$
  - $60\text{ V}$
  - $80\text{ V}$
  - $40\text{ V}$
- Two point charges  $100\text{ }\mu\text{C}$  and  $5\text{ }\mu\text{C}$  are placed at points  $A$  and  $B$  respectively with  $AB = 40\text{ cm}$ . The work done by external force in displacing the charge  $5\text{ }\mu\text{C}$  from  $B$  to  $C$ , where  $BC = 30\text{ cm}$ , angle  $ABC = \frac{\pi}{2}$  and  $\frac{1}{4\pi\epsilon_0} = 9 \times 10^9\text{ Nm}^2/\text{C}^2$ 
  - $9\text{ J}$
  - $\frac{81}{20}\text{ J}$
  - $\frac{9}{25}\text{ J}$
  - $-\frac{9}{4}\text{ J}$
- In the rectangle, shown below, the two corners have charges  $q_1 = -5\text{ }\mu\text{C}$  and  $q_2 = +2.0\text{ }\mu\text{C}$ . The work done in moving a charge  $+3.0\text{ }\mu\text{C}$  from  $B$  to  $A$  is (take  $1/4\pi\epsilon_0 = 10^{10}\text{ N.m}^2/\text{C}^2$ )
 
  - $2.8\text{ J}$
  - $3.5\text{ J}$
  - $4.5\text{ J}$
  - $5.5\text{ J}$

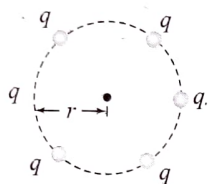


### 3.2 Electrostatics and Current Electricity

9. A charge  $(-q)$  and another charge  $(+Q)$  are kept at two points A and B respectively. Keeping the charge  $(+Q)$  fixed at B, the charge  $(-q)$  at A is moved to another point C such that ABC forms an equilateral triangle of side  $l$ . The net work done in moving the charge  $(-q)$  is

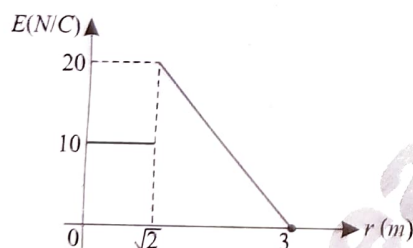
- (a)  $\frac{1}{4\pi\epsilon_0} \frac{Qq}{l}$  (b)  $\frac{1}{4\pi\epsilon_0} \frac{Qq}{l^2}$   
(c)  $\frac{1}{4\pi\epsilon_0} Qql$  (d) Zero

10. A point charge is surrounded symmetrically by six identical charges at distance  $r$  as shown in the figure. How much work is done by the forces of electrostatic repulsion when the point charge  $q$  at the centre is removed at infinity?



- (a) Zero (b)  $6q^2/4\pi\epsilon_0 r$   
(c)  $q^2/4\pi\epsilon_0 r$  (d)  $12q^2/4\pi\epsilon_0 r$

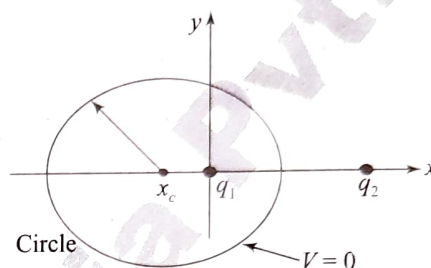
11. An electric field ' $E$ ' whose direction is radially outward varies as distance from origin ' $r$ ' as shown in the graph.  $E$  is taken as positive if its direction is away from the origin. Then the work done by electric field on a 2 C charge if it is taken from (1, 1, 0) to (3, 0, 0) is:



- (a)  $20(3 + \sqrt{2})J$  (b)  $-60 J$   
(c)  $60 J$  (d)  $20(3 - \sqrt{2})J$

### Comprehension Based

A point charge  $q_1 = +6e$  fixed at the origin of a coordinate system, and another point charge  $q_2 = -10e$  is fixed at  $x = 8 \text{ nm}$ ,  $y = 0$ . The locus of all points in the  $xy$  plane for which potential  $V = 0$  (other than infinity) is a circle centered on the  $x$ -axis, as shown.



12. Radius  $R$  of the circle is  
(a) 3 nm (b) 6 nm  
(c) 7.5 nm (d) 9 nm
13.  $x$ -coordinate of the centre of the circle is  
(a)  $-2 \text{ nm}$  (b)  $-3 \text{ nm}$   
(c)  $-4.5 \text{ nm}$  (d)  $-7.5 \text{ nm}$
14. The potential at the centre of the circle is  
(a) 0.32 V (b) 0.77 V  
(c) 1.2 V (d)  $-1.2 \text{ V}$

### Answers Key

#### Single Correct Answer Type

1. (d) 2. (c) 3. (b) 4. (b) 5. (c)  
6. (d) 7. (d) 8. (a) 9. (d) 10. (b)  
11. (d)

#### Comprehension Based

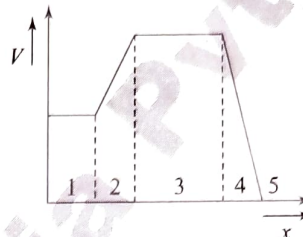
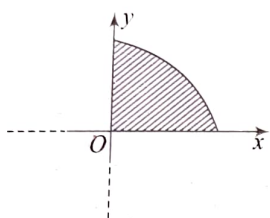
12. (c) 13. (c) 14. (b)

# DPP 3.2

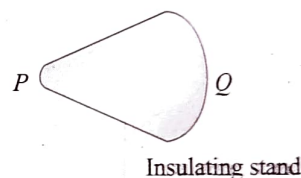
## Relation Between Field and Potential

### Subjective Type

1. A uniform surface charge of density  $\sigma$  is given to a quarter of a disc extending up to infinity in the first quadrant of  $x$ - $y$  plane. The centre of the disc is at the origin  $O$ . Find the  $z$ -component of the electric field at the point  $(0, 0, z)$  and the potential difference between the points  $(0, 0, d)$  and  $(0, 0, 2d)$ .



- (a)  $E_1 > E_2 > E_3 > E_4 > E_5$   
 (b)  $E_1 = E_3 = E_5$  and  $E_2 < E_4$   
 (c)  $E_2 = E_4 = E_5$  and  $E_1 < E_2$   
 (d)  $E_1 < E_2 < E_3 < E_4 < E_5$
7. Figure shows a charged conductor resting on an insulating stand. If at the point  $P$  the charge density is  $\sigma$ , the potential is  $V$  and the electric field strength is  $E$ , what are the values of these quantities at point  $Q$



### Single Correct Answer Type

2. The electric potential  $V$  at any point  $O(x, y, z)$  all in metres) in space is given by  $V = 4x^2$  volt. The electric field at the point  $(1 \text{ m}, 0, 2 \text{ m})$  in volt/metre is
- (a) 8 along negative  $X$ -axis  
 (b) 8 along positive  $X$ -axis  
 (c) 16 along negative  $X$ -axis  
 (d) 16 along positive  $Z$ -axis

3. Electric potential is given by

$$V = 6x - 8xy^2 - 8y + 6yz - 4z^2$$

Then electric force acting on  $2C$  point charge placed on origin will be

- (a) 2 N (b) 6 N (c) 8 N (d) 20 N
4. Consider two points 1 and 2 in a region outside a charged sphere. Two points are not very far away from the sphere. If  $E$  and  $V$  represent the electric field vector and the electric potential, which of the following is not possible
- (a)  $|\vec{E}_1| = |\vec{E}_2|, V_1 = V_2$  (b)  $\vec{E}_1 \neq \vec{E}_2, V_1 \neq V_2$   
 (c)  $\vec{E}_1 \neq \vec{E}_2, V_1 = V_2$  (d)  $|\vec{E}_1| = |\vec{E}_2|, V_1 \neq V_2$
5. Electric potential at any point is  $V = -5x + 3y + \sqrt{15}z$ , then the magnitude of the electric field is
- (a)  $3\sqrt{2}$  (b)  $4\sqrt{2}$  (c)  $5\sqrt{2}$  (d) 7
6. The figure gives the electric potential  $V$  as a function of distance through five regions on  $x$ -axis. Which of the following is true for the electric field  $E$  in these regions?

Charge density    Potential    Electric intensity

- (a)  $> \sigma$      $> V$      $> E$   
 (b)  $> \sigma$      $V$      $> E$   
 (c)  $< \sigma$      $V$      $E$   
 (d)  $< \sigma$      $V$      $< E$

8. The electrostatic potential on the surface of a charged conducting sphere is 100 V. Two statements are made in this regard

$S_1$ : at any point inside the sphere, electric intensity is zero.  
 $S_2$ : at any point inside the sphere, the electrostatic potential is 100 V.

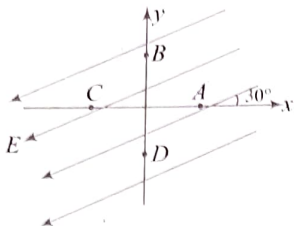
Which of the following is a correct statement?

- (a)  $S_1$  is true but  $S_2$  is false  
 (b) Both  $S_1$  and  $S_2$  are false  
 (c)  $S_1$  is true,  $S_2$  is also true and  $S_1$  is the cause of  $S_2$   
 (d)  $S_1$  is true,  $S_2$  is also true but the statements are independent
9. If uniform electric field  $\vec{E} = E_0\hat{i} + 2E_0\hat{j}$ , where  $E_0$  is a constant existing in a region of space and at  $(0, 0)$  the electric potential  $V$  is zero, then the potential at  $(x_0, 0)$  will be
- (a) zero (b)  $-E_0 x_0$   
 (c)  $-2E_0 x_0$  (d)  $-\sqrt{5} E_0 x_0$



### 3.4 Electrostatics and Current Electricity

10. There exists a uniform electric field in the space as shown. Four points A, B, C and D are marked which are equidistant from the origin. If  $V_A$ ,  $V_B$ ,  $V_C$  and  $V_D$  are their potentials respectively, then



- (a)  $V_B > V_A > V_C > V_D$  (b)  $V_A > V_B > V_D > V_C$   
 (c)  $V_A = V_B > V_C = V_D$  (d)  $V_B > V_C > V_A > V_D$
11. The potential field of an electric field  $\vec{E} = (y\hat{i} + x\hat{j})$  is  
 (a)  $V = -xy + \text{constant}$   
 (b)  $V = -(x + y) + \text{constant}$   
 (c)  $V = -(x^2 + y^2) + \text{constant}$   
 (d)  $V = \text{constant}$
12. A uniform electric field exists in x-y plane. The potential of points A(-2m, 2m), B(-2m, 2m) and C(2m, 4m) are 4 V, 16 V and 12 V respectively. The electric field is  
 (a)  $(4\hat{i} + 5\hat{j}) \frac{\text{V}}{\text{m}}$  (b)  $(3\hat{i} + 4\hat{j}) \frac{\text{V}}{\text{m}}$   
 (c)  $-(3\hat{i} + 4\hat{j}) \frac{\text{V}}{\text{m}}$  (d)  $(3\hat{i} - 4\hat{j}) \frac{\text{V}}{\text{m}}$
13. Four similar charges each of charge +q are placed at four corners of a square of side a. Find the value of integral

$$-\int_{-\infty}^{a/\sqrt{2}} \vec{E} \cdot d\vec{r} \text{ (in volts) if value of integral}$$

$$-\int_{a/\sqrt{2}}^0 \vec{E} \cdot d\vec{r} = \frac{\sqrt{2}Kq}{a} \left( \text{where } K = \frac{1}{4\pi\epsilon_0} \right)$$

(a)  $\frac{4Kq}{a}$

(b)  $\frac{3Kq}{a}$

(c)  $\frac{3\sqrt{2}Kq}{a}$

(d)  $\frac{4\sqrt{2}Kq}{a}$

### Multiple Correct Answers Type

14. Two infinite, parallel, non-conducting sheets carry equal positive charge density  $\sigma$ . One is placed in the yz plane and the other at distance  $x = a$ . Take potential  $V = 0$  at  $x = 0$ .  
 (a) For  $0 \leq x \leq a$ , potential  $V_x = 0$ .  
 (b) For  $x \geq a$ , potential  $V_x = -\frac{\sigma}{\epsilon_0}(x - a)$   
 (c) For  $x \geq a$ , potential  $V_x = \frac{\sigma}{\epsilon_0}(x - a)(X - a)$   
 (d) For  $x \leq 0$  potential  $V_x = \frac{\sigma}{\epsilon_0}x$
15. About an electric field which of the following statements are not true?  
 (a) If  $E = 0$ ,  $V$  must be zero  
 (b) If  $V = 0$ ,  $E$  must be zero  
 (c) If  $E \neq 0$ ,  $V$  cannot be zero  
 (d) If  $V \neq 0$ ,  $E$  cannot be zero

### Answers Key

#### Subjective Type

1.  $\frac{\sigma}{8\epsilon_0}$

#### Single Correct Answer Type

2. (a) 3. (d) 4. (d) 5. (d) 6. (b)

7. (d) 8. (c) 9. (b) 10. (b) 11. (a)  
 12. (d) 13. (c)

#### Multiple Correct Answers Type

14. (a,b,d) 15. (a, b, c, d)

# DPP 3.3

## Equipotential Surfaces

### Subjective Type

- Two metal spheres, one of radius  $R$  and the other of radius  $2R$ , both have same surface charge density  $\sigma$ . They are brought in contact and separated. What will be new surface charge densities on them?
- Two charges  $q_1$  and  $q_2$  are placed at  $(0, 0, d)$  and  $(0, 0, -d)$  respectively. Find locus of points where the potential is zero.

### Single Correct Answer Type

- Equipotentials at a great distance from a collection of charges whose total sum is not zero are approximately
  - spheres
  - planes
  - paraboloids
  - ellipsoids
- Figure shows some equipotential lines distributed in space. A charged object is moved from point A to point B.
  - The work done in Fig. (i) is the greatest
  - The work done in Fig. (ii) is the least
  - The work done is the same in Fig. (i), Fig. (ii) and Fig. (iii).
  - The work done in Fig. (iii) is greater than Fig. (ii) but equal to that in Fig. (i)

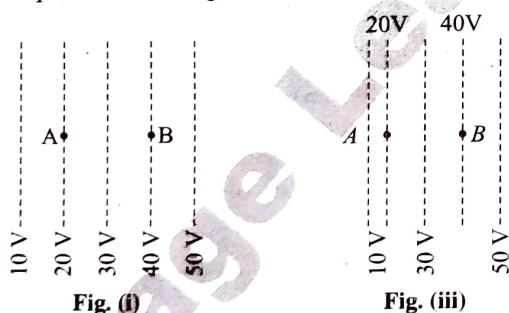


Fig. (i)

Fig. (iii)

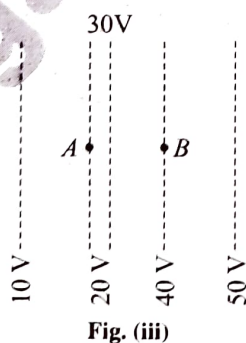
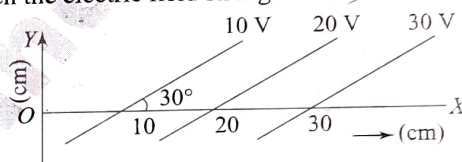
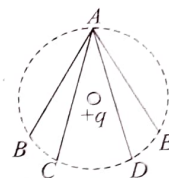
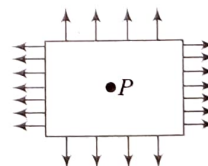
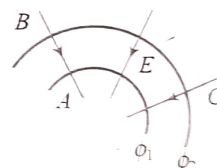


Fig. (ii)

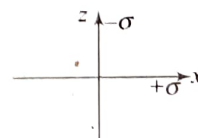
- In the electric field of a point charge  $q$ , a certain charge is carried from point A to B, C, D and E. Then the work done
  - is least along the path AB
  - is least along the path AD
  - is zero along all the paths AB, AC, AD and AE
  - is least along AE
- Equipotential surfaces are shown in the following figure. Then the electric field strength will be



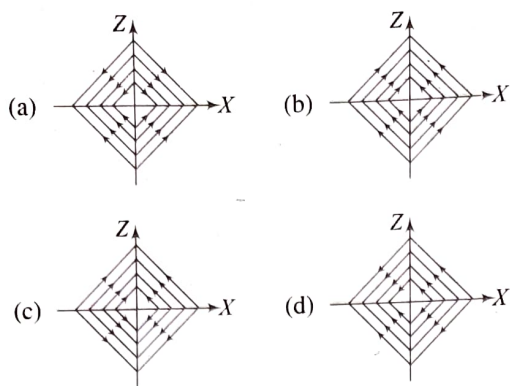
- $100 \text{ Vm}^{-1}$  along X-axis
  - $100 \text{ Vm}^{-1}$  along Y-axis
  - $200 \text{ Vm}^{-1}$  at an angle  $120^\circ$  with X-axis
  - $50 \text{ Vm}^{-1}$  at an angle  $120^\circ$  with X-axis
- In moving from A to B along an electric field line, the electric field does  $6.4 \times 10^{-19} \text{ J}$  of work on an electron. If  $\phi_1$  and  $\phi_2$  are equipotential surfaces, then the potential difference  $(V_C - V_A)$  is
    - 4 V
    - 4 V
    - Zero
    - 64 V
  - Electric lines of force are as shown in the figure. Then potential at point P.



- is zero
  - is not zero
  - may be zero also
  - is not defined
- Two infinitely large charged planes having uniform surface charge density  $+\sigma$  and  $-\sigma$  are placed along x-y plane and yz plane respectively as shown in the figure. Then the nature of electric lines of forces in x-z plane is given by:





**Multiple Correct Answers Type**

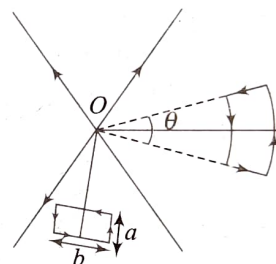
10. Equipotential surfaces
- are closer in regions of large electric fields compared to regions of lower electric fields
  - will be more crowded near sharp edges of a conductor
  - will be more crowded near regions of large charge densities
  - will always be equally spaced
11. Consider a uniform electric field in the  $\hat{z}$ -direction. The potential is a constant
- in all space
  - for any  $x$  for a given  $z$
  - for any  $y$  for a given  $z$
  - on the  $x$ - $y$  plane for a given  $z$
12. Across the surface of a charged conductor, the electric:
- field is continuous
  - potential is continuous
  - field is discontinuous
  - potential is discontinuous
13. Mark the correct statements:
- a given conducting sphere can be charged to any extent
  - a given conducting sphere cannot be charged to a potential greater than a certain value
  - a given conducting sphere cannot be charged to a potential less than a certain minimum value
  - none of the above

14. A conducting sphere of radius  $R$  has a charge. Then:
- the charge is uniformly distributed over its surface, if there is no external electric field
  - distribution of charge over its surface will be non-uniform, if an external electric field exists in the space
  - the electric field strength inside the sphere will be equal to zero only when no external electric field exists
  - potential at every point of the sphere must be the same

**True and False Type**

State whether the statement is true or false:

15. Consider two conducting spheres of radii  $R_1$  and  $R_2$  with  $R_1 > R_2$ . If the two are at the same potential, the larger sphere has more charge than the smaller sphere, then charge density of the smaller sphere is more than that of the larger one.
16. Free electrons travel to region of higher potential or lower potential.
17. There may be a potential difference between two adjacent conductors carrying the same charge.
18. A test charge  $q$  is made to move in the electric field of a point charge  $Q$  along two different closed paths (see figure). First path has sections along and perpendicular to lines of electric field. Second path is a rectangular loop of the same area as the first loop. The work done in the first path is more than that of the second path.



19. A closed equipotential surface with no charge within itself must enclose an equipotential volume.
20. If an insulated, uncharged conductor is placed near a charged conductor and no other conductors are present, the uncharged body must intermediate in potential between that of the charged body and that of infinity.

**Answers Key****Subjective Type**

1.  $\sigma_1 = \frac{5}{3}\sigma$  and  $\sigma_2 = \frac{5}{6}\sigma$

**Single Correct Answer Type**

3. (a)    4. (c)    5. (c)    6. (c)    7. (b)  
8. (b)    9. (c)

**Multiple Correct Answers Type**

10. (a, b, c)    11. (b, c, d)    12. (b, c)  
13. (b, c)    14. (a, d)

**True and False Type**

15. (True)    16. (False)    17. (True)  
18. (False)    19. (True)    20. (True)

# DPP 3.4

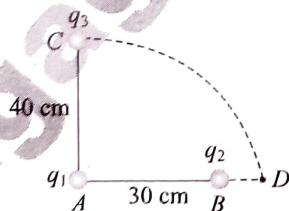
## Electric Potential Energy

### Subjective Type

1. Two charges  $-q$  each are separated by distance  $2d$ . A third charge  $+q$  is kept at mid-point  $O$ . Find potential energy of  $+q$  as a function of small distance  $x$  from  $O$  due to  $-q$  charges. Prove that the charge at  $O$  is in an unstable equilibrium.

### Single Correct Answer Type

2. A positively charged particle is released from rest in a uniform electric field. The electric potential energy of the charge
- remains a constant because the electric field is uniform
  - increases because the charge moves along the electric field
  - decreases because the charge moves along the electric field
  - decreases because the charge moves opposite to the electric field
3. If identical charges  $(-q)$  are placed at each corner of a cube of side  $b$ , then electric potential energy of charge  $(+q)$  which is placed at centre of the cube will be
- $\frac{8\sqrt{2}q^2}{4\pi\epsilon_0 b}$
  - $\frac{-8\sqrt{2}q^2}{\pi\epsilon_0 b}$
  - $\frac{-4\sqrt{2}q^2}{\pi\epsilon_0 b}$
  - $\frac{-4q^2}{\sqrt{3}\pi\epsilon_0 b}$
4. Two charges  $q_1$  and  $q_2$  are placed 30 cm apart, shown in the figure. A third charge  $q_3$  is moved along the arc of a circle of radius 40 cm from  $C$  to  $D$ . The change in the potential energy of the system is  $\frac{q_3}{4\pi\epsilon_0} k$ , where  $k$  is



- $8q_2$
  - $8q_1$
  - $6q_2$
  - $6q_1$
5. A charged particle of charge ' $Q$ ' is held fixed and another charged particle of mass ' $m$ ' and charge ' $q$ ' (of the same sign) is released from a distance ' $r$ '. The impulse of the force exerted by the external agent on the fixed charge by the time distance between ' $Q$ ' and ' $q$ ' becomes  $2r$  is

(a)  $\sqrt{Qq/4\pi\epsilon_0 mr}$

(b)  $\sqrt{Qqm/4\pi\epsilon_0 r}$

(c) 0

(d) cannot determine

6. A very large sphere having charge  $Q$  uniformly distributed on the surface is compressed uniformly till its radius reduces to  $R$ . The work done by the electric forces in this process is:

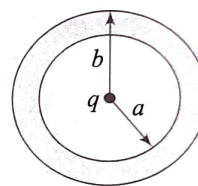
(a)  $\frac{Q^2}{8\pi\epsilon_0 R}$

(b)  $\frac{-Q^2}{8\pi\epsilon_0 R}$

(c)  $\infty$

(d) 0

7. In the figure shown the electric potential energy of the system is: ( $q$  is at the centre of the conducting neutral spherical shell of inner radius  $a$  and outer radius  $b$ )



(a) 0

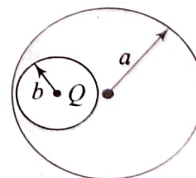
(b)  $\frac{kq^2}{2b}$

(c)  $\frac{kq^2}{2b} - \frac{kq^2}{2a}$

(d)  $\frac{kq^2}{2a} - \frac{kq^2}{2b}$

8. A point charge ' $Q$ ' is placed at the centre of a spherical cavity of radius ' $b$ ' carved inside a solid conducting sphere of radius ' $a$ '. Then total energy of the system is:

$\left[ k = \frac{1}{4\pi\epsilon_0} \right]$



(a)  $\frac{kQ^2}{2a} - \frac{kQ^2}{2b}$

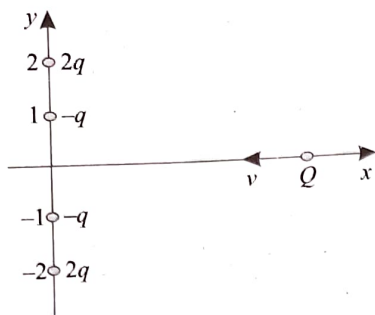
(b)  $\frac{kQ^2}{2a} + \frac{kQ^2}{2b}$

(c)  $\frac{kQ^2}{a} + \frac{kQ^2}{b}$

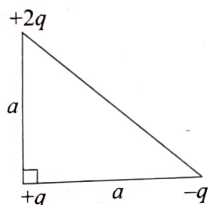
(d)  $\frac{kQ^2}{a} - \frac{kQ^2}{b}$

9. Four charges are rigidly fixed along the  $y$ -axis as shown. A positive charge approaches the system along the  $x$ -axis with initial speed just enough to cross the origin. Then its total energy at the origin is



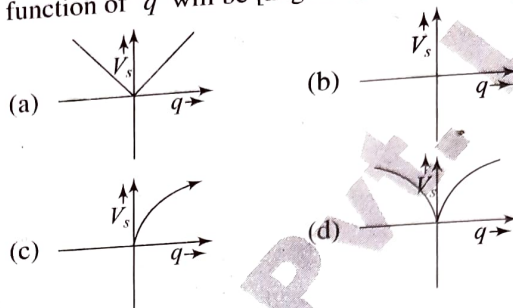


- (a) zero (b) positive  
(c) negative (d) data insufficient
10. Three charges  $+q$ ,  $-q$ , and  $+2q$  are placed at the vertices of a right angled triangle (isosceles triangle) as shown. The net electrostatic energy of the configuration is:



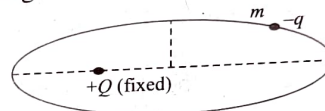
- (a)  $-\frac{Kq^2}{a}(\sqrt{2}+1)$  (b)  $\frac{Kq^2}{a}(\sqrt{2}+1)$   
(c)  $-\frac{Kq^2}{a}(\sqrt{2}-1)$  (d) None of these
11. Three equal charges  $Q$  are placed at the three vertices of an equilateral triangle. What should be the value of a charge that when placed at the centroid reduces the interaction energy of the system to zero:  
(a)  $\frac{-Q}{2}$  (b)  $\frac{-Q}{3}$  (c)  $\frac{-Q}{2\sqrt{3}}$  (d)  $\frac{-Q}{\sqrt{3}}$
12. You are moving a negative charge  $q < 0$  at a small constant speed away from a uniformly charged non-conducting spherical shell on which resides a negative charge  $Q < 0$ . The electrostatic field of  $Q$  is  $E$ . Let  $U$  be the total energy of the system,  $W_a$  the work done by the force  $F_a$  you exert on  $q$ ,  $W_E$  the work done by the electrostatic force  $F_E$  on  $q$ . Then, as  $q$  is being moved:  
(a)  $W_a = -W_E$ , therefore  $U$  remains constant  
(b)  $F_a = -F_E$   
(c)  $U$  increases  
(d)  $U$  decreases

13. A negative charge  $Q$  is distributed uniformly in volume of a sphere of radius  $R$  and a point charge particle (may be negative or positive) is present on the surface of this sphere, then the variation of escape velocity ( $v_s$ ) of charge ' $q$ ' as a function of ' $q$ ' will be [neglect gravitational interaction]



### Multiple Correct Answers Type

14. A positive point charge  $+Q$  is fixed in space. A negative point charge  $-q$  of mass  $m$  revolves around fixed charge in elliptical orbit. The fixed charge  $+Q$  is at one focus of the ellipse. The only force acting on negative charge is the electrostatic force due to positive charge. Then which of the following statement is true.



- (a) Linear momentum of negative point charge is conserved  
(b) Angular momentum of negative point charge about fixed positive charge is conserved  
(c) Total kinetic energy of negative point charge is conserved  
(d) The sum of electrostatic potential energy and kinetic energy of system of both point charges is conserved
15. Small identical balls with equal charges are fixed at the vertices of a regular polygon of  $N$  sides, each of length  $d$ . At a certain instant, one of the ball is released. After a long time interval, the adjacent ball to the previous one is released. The difference in kinetic energies of the two released balls is  $K$  at a sufficiently long distance from the polygon.  
(a) Final kinetic energy of the first ball is greater than that of the second ball.  
(b) Final kinetic energy of the second ball is greater than that of the first ball.  
(c) Charge on each ball is  $\sqrt{2\pi\epsilon_0 dK}$   
(d) Charge on each ball is  $\sqrt{4\pi\epsilon_0 dK}$

### Answers Key

#### Subjective Type

1.  $\frac{-q^2}{4\pi\epsilon_0(d^2 - x^2)}$

#### Single Correct Answer Type

2. (c) 3. (d) 4. (a) 5. (b) 6. (b)

7. (c) 8. (a) 9. (b) 10. (c) 11. (d)  
12. (d) 13. (c)

#### Multiple Correct Answers Type

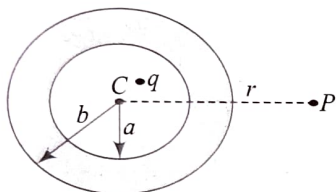
14. (b,d) 15. (a,d)

# DPP 3.5

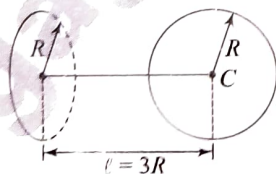
## Potential Due to Continuous Structures

### Subjective Type

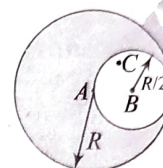
1. In the figure shown a conducting sphere of inner radius ' $a$ ' and outer radius ' $b$ ' is given a charge  $Q$ . A point charge ' $q$ ' is placed in the cavity of this sphere at distance ' $x$ ' ( $< a$ ) away from the centre. Find the electric field intensity and electric potentials at point  $P$  (outside the sphere) at distance  $r > b$ . Also find the electric potential at point  $C$ .



2. A point charge  $Q$  is situated (outside) at a distance  $r$  from the centre of an uncharged conducting solid sphere of radius  $R$ . The potential due to induced charges (on the conductor) at a point  $B$  inside the conductor whose distance from the point charge is  $d$  is \_\_\_\_\_.
3. Find the electric potential and strength at the centre of a hemispherical shell of radius  $R$  charged uniformly with the surface density  $\sigma$ .
4. There are three concentric conducting spherical shells. All of them are charged. The innermost sphere is connected by a conducting wire to the outermost sphere. Prove that the final charge on the innermost sphere is independent of the initial charge of outermost sphere.
5. Both the ring and the conducting sphere are given the same charge  $Q$ . Determine the potential of the sphere. Assume that the centre of the sphere lies on the axis of the ring. Is it necessary that the charge on the ring be uniformly distributed to answer the above question?



6. A solid sphere of radius ' $R$ ' has a cavity of radius  $\frac{R}{2}$ . The solid part has a uniform charge density ' $\rho$ ' and cavity has no charge. Find the electric potential at point ' $A$ '. Also find the electric field (only magnitude) at point ' $C$ ' inside the cavity.



### Single Correct Answer Type

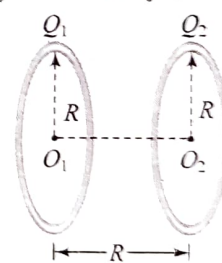
7. A thin spherical conducting shell of radius  $R$  has a charge  $q$ . Another charge  $Q$  is placed at the centre of the shell. The electrostatic potential at a point  $p$  at a distance  $\frac{R}{2}$  from the centre of the shell is

(a)  $\frac{(q+Q)2}{4\pi\epsilon_0 R}$  (b)  $\frac{2Q}{4\pi\epsilon_0 R}$   
 (c)  $\frac{2Q}{4\pi\epsilon_0 R} - \frac{2q}{4\pi\epsilon_0 R}$  (d)  $\frac{2Q}{4\pi\epsilon_0 R} + \frac{q}{4\pi\epsilon_0 R}$

8. An arc of radius  $r$  carries charge. The linear density of charge is  $\lambda$  and the arc subtends an angle  $\frac{\pi}{3}$  at the centre. What is electric potential at the centre?

(a)  $\frac{\lambda}{4\epsilon_0}$  (b)  $\frac{\lambda}{8\epsilon_0}$  (c)  $\frac{\lambda}{12\epsilon_0}$  (d)  $\frac{\lambda}{16\epsilon_0}$

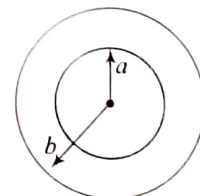
9. Two identical thin rings each of radius  $R$  meters are coaxially placed at a distance  $R$  meters apart. If  $Q_1$  coulomb and  $Q_2$  coulomb are respectively the charges uniformly spread on the two rings, the work done in moving a charge  $q$  from the centre of one ring to that of other is



(a) Zero (b)  $\frac{q(Q_1 - Q_2)(\sqrt{2} - 1)}{\sqrt{2} \cdot 4\pi\epsilon_0 R}$   
 (c)  $\frac{q\sqrt{2}(Q_1 + Q_2)}{4\pi\epsilon_0 R}$  (d)  $\frac{q(Q_1 + Q_2)(\sqrt{2} + 1)}{\sqrt{2} \cdot 4\pi\epsilon_0 R}$

10. If the electric potential of the inner shell is 10 volt and that of the outer shell is 5 volt, then the potential at the centre will be: (the shells are uniformly charged)

- (a) 10 volt  
 (b) 5 volt  
 (c) 15 volt  
 (d) 0





### 3.10 Electrostatics and Current Electricity

11. Potential difference between centre and the surface of sphere of radius  $R$  and having uniform volume charge density  $\rho$  within it will be:

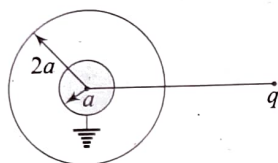
(a)  $\frac{\rho R^2}{6\epsilon_0}$  (b)  $\frac{\rho R^2}{4\epsilon_0}$  (c) 0 (d)  $\frac{\rho R^2}{2\epsilon_0}$

12. A mercury drop of water has potential ' $V$ ' on its surface. 1000 such drops combine to form a new drop. Find the potential on the surface of the new drop.

(a)  $V$  (b)  $10V$  (c)  $100V$  (d)  $1000V$

#### Comprehension Based

A solid conducting sphere of radius ' $a$ ' is surrounded by a thin uncharged concentric conducting shell of radius  $2a$ . A point charge  $q$  is placed at a distance  $4a$  from common centre of conducting sphere and shell. The inner sphere is then grounded.



13. The charge on solid sphere is:

(a)  $-\frac{q}{2}$  (b)  $-\frac{q}{4}$   
(c)  $-\frac{q}{8}$  (d)  $-\frac{q}{16}$

14. Pick up the correct statement.

- (a) Charge on surface of inner sphere is non-uniformly distributed.  
(b) Charge on inner surface of outer shell is non-uniformly distributed.  
(c) Charge on outer surface of outer shell is non-uniformly distributed.  
(d) All the above statements are false.

15. The potential of outer shell is

(a)  $\frac{q}{32\pi\epsilon_0 a}$  (b)  $\frac{q}{16\pi\epsilon_0 a}$   
(c)  $\frac{q}{8\pi\epsilon_0 a}$  (d)  $\frac{q}{4\pi\epsilon_0 a}$

### Answers Key

#### Subjective Type

5.  $\frac{kQ}{R\sqrt{10}} + \frac{kQ}{R}$ , No

6.  $V_A = \frac{5\rho R^2}{12\epsilon_0}$ ,  $E_C = \frac{\rho R}{6\epsilon_0}$

#### Single Correct Answer Type

7. (d) 8. (c) 9. (b) 10. (a) 11. (a)  
12. (c)

#### Comprehension Based

13. (b) 14. (c) 15. (a)

# Capacitor and Capacitance

## DPP 4.1

### Capacitance

#### Subjective Type

1. A parallel plate capacitor is to be designed which is to be connected across 1 kV potential difference. The dielectric material which is to be filled between the plates has dielectric constant  $K = 6\pi$  and dielectric strength  $10^7$  V/m.

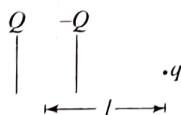
For safety the electric field is never to exceed 10% of the dielectric strength. With such specifications, if we want a capacitor of capacitance 50 pF, what minimum area (in  $\text{mm}^2$ ) of plates is required for safe working?

$$\left( \text{use } \epsilon_0 = \frac{1}{36\pi} \times 10^{-9} \text{ in MKS} \right)$$

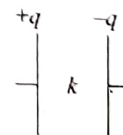
2. A parallel plate capacitor is filled by a dielectric whose dielectric constant varies with the applied voltage ( $V$ ) as  $K = 2V$ . A similar capacitor with no dielectric is charged to  $V_0 = 78$  volt. It is then connected to the uncharged capacitor with the dielectric. Find the final voltage on the capacitors.

#### Single Correct Answer Type

3. The plates of small size of a parallel plate capacitor are charged as shown. The force on the charged particle of ' $q$ ' at a distance ' $l$ ' from the capacitor is: (Assume that the distance between the plates is  $d \ll l$ )



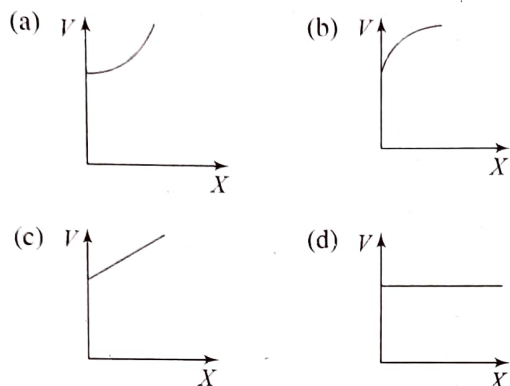
- (a) zero
  - (b)  $\frac{Qqd}{2\pi\epsilon_0 l^3}$
  - (c)  $\frac{Qqd}{\pi\epsilon_0 l^3}$
  - (d)  $\frac{Qqd}{4\pi\epsilon_0 l^3}$
4. The true statement is, on increasing the distance between the plates of a parallel plate condenser,
    - (a) The electric intensity between the plates will decrease
    - (b) The electric intensity between the plates will increase
    - (c) The electric intensity between the plates will remain unchanged
    - (d) The PD between the plates will decrease
  5. An isolated capacitor has charge  $Q$  and plate area  $A$ . Between the plates of a parallel plate condenser, a plate of thickness  $t_1$  and dielectric constant  $k_1$  is placed. In the rest of the space, there is another plate of thickness  $t_2$  and dielectric constant  $k_2$ . The potential difference across the condenser will be
    - (a)  $\frac{Q}{A\epsilon_0} \left( \frac{t_1}{k_1} + \frac{t_2}{k_2} \right)$
    - (b)  $\frac{\epsilon_0 Q}{A} \left( \frac{t_1}{k_1} + \frac{t_2}{k_2} \right)$
    - (c)  $\frac{Q}{A\epsilon_0} \left( \frac{k_1}{t_1} + \frac{k_2}{t_2} \right)$
    - (d)  $\frac{\epsilon_0 Q}{A} (k_1 t_1 + k_2 t_2)$
  6. Force of attraction between the plates of area  $A$  of a parallel plate capacitor is
    - (a)  $\frac{q^2}{2\epsilon_0 AK}$
    - (b)  $\frac{q^2}{\epsilon_0 AK}$
    - (c)  $\frac{q}{2\epsilon_0 A}$
    - (d)  $\frac{q^2}{2\epsilon_0 A^2 K}$





## 4.2 Electrostatics and Current Electricity

7. Between the plates of a parallel plate capacitor, a dielectric plate is introduced just to fill the space between the plates. The capacitor is charged and later disconnected from the battery. The dielectric plate is slowly drawn out of the capacitor parallel to the plates. The plot of the potential difference across the plates and the length of the dielectric plate drawn out is



8. A capacitor is charged by using a battery which is then disconnected. A dielectric slab is then slipped between the plates, which results in

- reduction of charge on the plates and increase of potential difference across the plates
- increase in the potential difference across the plate, reduction in stored energy, but no change in the charge on the plates
- decrease in the potential difference across the plates, reduction in the stored energy, but no change in the charge on the plates
- none of the above

9. The capacity and the energy stored in a parallel plate condenser with air between its plates are respectively  $C_0$  and  $W_0$ . If the air is replaced by glass (dielectric constant = 5) between the plates, the capacity of the plates and the energy stored in it will respectively be

- $5C_0, 5W_0$
- $5C_0, \frac{W_0}{5}$
- $\frac{C_0}{5}, 5W_0$
- $\frac{C_0}{5}, \frac{W_0}{5}$

10. A parallel plate capacitor having a plate separation of 2 mm is charged by connecting it to a 300 V supply. The energy density is

- $0.01 \text{ J/m}^3$
- $0.1 \text{ J/m}^3$
- $1.0 \text{ J/m}^3$
- $10 \text{ J/m}^3$

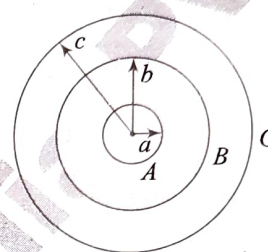
11. A parallel plate capacitor (without dielectric) is charged by a battery and kept connected to the battery. A dielectric slab of dielectric constant ' $k$ ' is inserted between the plates fully occupying the space between the plates. The energy density of electric field between the plates will:

- increase  $k^2$  times
- decrease  $k^2$  times
- increase  $k$  times
- decrease  $k$  times

12. An uncharged parallel plate capacitor is connected to a battery. The electric field between the plates is  $10 \text{ V/m}$ . Now a dielectric of dielectric constant 2 is inserted between the plates filling the entire space. The electric field between the plates now is

- $5 \text{ V/m}$
- $20 \text{ V/m}$
- $10 \text{ V/m}$
- none of these

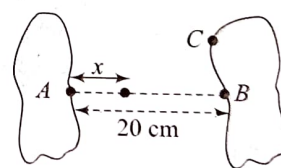
13. A and C are concentric conducting spherical shells of radius  $a$  and  $c$  respectively. A is surrounded by a concentric dielectric medium of inner radius  $a$ , outer radius  $b$  and dielectric constant  $k$ . If sphere A is given a charge  $Q$ , the potential at the outer surface of the dielectric is



- $\frac{Q}{4\pi\epsilon_0 kb}$
- $\frac{Q}{4\pi\epsilon_0} \left( \frac{1}{a} + \frac{1}{k(b-a)} \right)$
- $\frac{Q}{4\pi\epsilon_0 b}$
- None of these

### Multiple Correct Answers Type

14. Two metallic bodies separated by a distance 20 cm are given equal and opposite charges of magnitude  $0.88 \mu\text{C}$ . The component of electric field along the line AB, between the plates, varies as  $E_x = 3x^2 + 0.4 \text{ N/C}$ , where  $x$  (in meters) is the distance from one body towards the other body as shown.



- The capacitance of the system is  $10 \mu\text{F}$
  - The capacitance of the system is  $20 \mu\text{F}$
  - The potential difference between A and C is 0.88 volt.
  - The potential difference between A and C cannot be determined from the given data.
15. The plates of a parallel plate capacitor with no dielectric are connected to a voltage source. Now a dielectric of dielectric constant  $K$  is inserted to fill the whole space between the plates with voltage source remaining connected to the capacitor.
- The energy stored in the capacitor will become  $K$  times
  - The electric field inside the capacitor will decrease  $K$  times
  - The force of attraction between the plates will become  $K^2$  times
  - The charge on the capacitor will become  $K$  times.

---

**Answers Key**

---

**Subjective Type**

1.  $300 \text{ mm}^2$       2. 6 volt

**Single Correct Answer Type**

3. (b)      4. (c)      5. (a)      6. (a)      7. (b)  
8. (c)      9. (b)      10. (b)      11. (c)      12. (c)  
13. (c)

**Multiple Correct Answers Type**

14. (a, c)      15. (a, c, d)

Cengage Learning India Pvt. Ltd.

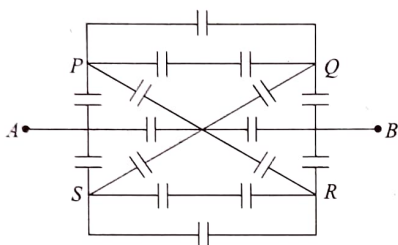


# DPP 4.2

## Series and Parallel Combination of Capacitors 1

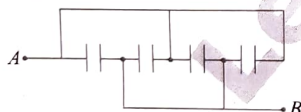
### Subjective Type

1. If each capacitor is of capacity  $C$ , find the capacitance between  $A$  and  $B$ .

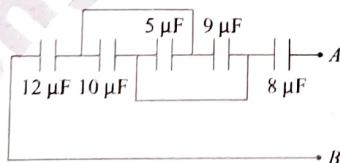


### Single Correct Answer Type

2. The two metallic plates of radius  $r$  are placed at a distance  $d$  apart and its capacity is  $C$ . If a plate of radius  $r/2$  and thickness  $d$  of dielectric constant 6 is placed between the plates of the condenser, then its capacity will be  
(a)  $7C/2$  (b)  $3C/7$  (c)  $7C/3$  (d)  $9C/4$
3. Four condensers are joined as shown in the adjoining figure. The capacity of each is  $8\mu\text{F}$ . The equivalent capacity between the points  $A$  and  $B$  will be

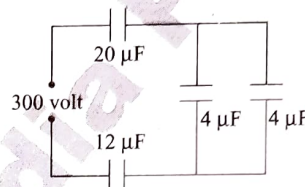


- (a)  $32\mu\text{F}$  (b)  $2\mu\text{F}$   
(c)  $8\mu\text{F}$  (d)  $16\mu\text{F}$
4. The capacities and connection of five capacitors are shown in the adjoining figure. The potential difference between the points  $A$  and  $B$  is 60 volts. Then the equivalent capacity between  $A$  and  $B$  and the charge on  $5\mu\text{F}$  capacitance will be respectively

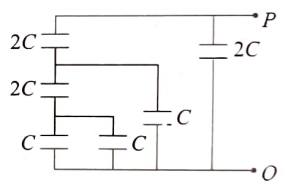


- (a)  $44\mu\text{F}$ ;  $300\mu\text{C}$  (b)  $16\mu\text{F}$ ;  $150\mu\text{C}$   
(c)  $15\mu\text{F}$ ;  $200\mu\text{C}$  (d)  $4\mu\text{F}$ ;  $50\mu\text{C}$

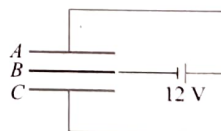
5. In the adjoining figure, four capacitors are shown with their respective capacities and the PD applied. The charge and the PD across the  $4\mu\text{F}$  capacitor will be



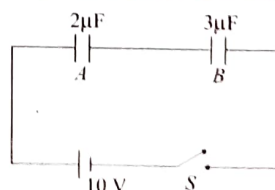
- (a)  $600\mu\text{C}$ ; 150 volts (b)  $300\mu\text{C}$ ; 75 volts  
(c)  $800\mu\text{C}$ ; 200 volts (d)  $580\mu\text{C}$ ; 145 volts
6. The resultant capacitance of given circuit is  
(a)  $3C$  (b)  $2C$   
(c)  $C$  (d)  $\frac{C}{3}$



7. Three plates  $A$ ,  $B$  and  $C$  each of area  $50\text{ cm}^2$  have separation 3 mm between  $A$  and  $B$  and 3 mm between  $B$  and  $C$ . The energy stored when the plates are fully charged is

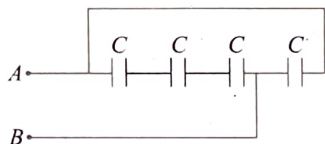


- (a)  $1.6 \times 10^{-9}\text{ J}$  (b)  $2.1 \times 10^{-9}\text{ J}$   
(c)  $5 \times 10^{-9}\text{ J}$  (d)  $7 \times 10^{-9}\text{ J}$
8. Two capacitors  $A$  and  $B$  are connected in series with a battery as shown in the figure. When the switch  $S$  is closed and the two capacitors get charged fully, then

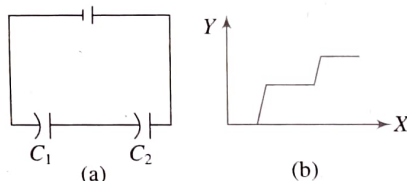


- (a) The potential difference across the plates of  $A$  is  $4\text{ V}$  and across the plates of  $B$  is  $6\text{ V}$   
 (b) The potential difference across the plates of  $A$  is  $6\text{ V}$  and across the plates of  $B$  is  $4\text{ V}$   
 (c) The ratio of electrical energies stored in  $A$  and  $B$  is  $2 : 3$   
 (d) The ratio of charges on  $A$  and  $B$  is  $3 : 2$
9. Two identical capacitors have the same capacitance  $C$ . The equivalent capacitance between  $A$  and  $B$  is

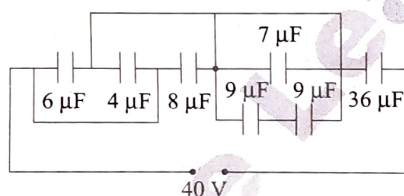
- (a)  $\frac{C}{4}$  (b)  $\frac{3C}{4}$  (c)  $\frac{C}{3}$  (d)  $\frac{4C}{3}$



10. Figure (a) shows two capacitors connected in series and joined to a battery. The graph in Figure (b) shows the variation in potential as one moves from left to right on the branch containing the capacitors, if
- (a)  $C_1 > C_2$  (b)  $C_1 = C_2$   
 (c)  $C_1 < C_2$   
 (d) The information is not sufficient to decide the relation between  $C_1$  and  $C_2$

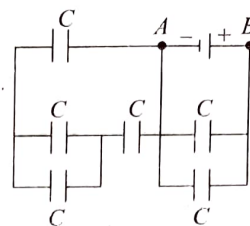


11. In the following diagram, the charge and potential difference across  $8\text{ }\mu\text{F}$  capacitance will be respectively



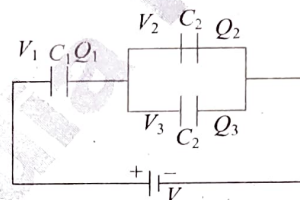
- (a)  $320\text{ }\mu\text{C}$ ,  $40\text{ V}$  (b)  $420\text{ }\mu\text{C}$ ,  $50\text{ V}$   
 (c)  $214\text{ }\mu\text{C}$ ,  $27\text{ V}$  (d)  $360\text{ }\mu\text{C}$ ,  $45\text{ V}$

12. Find equivalent capacitance between  $A$  and  $B$

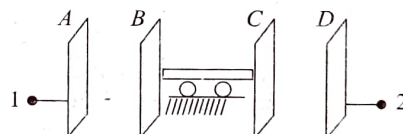


- (a)  $6C$  (b)  $5C$   
 (c)  $3C$  (d)  $2C$

13. In an adjoining figure are shown three capacitors  $C_1$ ,  $C_2$  and  $C_3$  joined to a battery. The correct condition will be (Symbols have their usual meanings)



- (a)  $Q_1 = Q_2 = Q_3$  and  $V_1 = V_2 + V_3 = V$   
 (b)  $Q_1 = Q_2 + Q_3$  and  $V = V_1 + V_2 + V_3$   
 (c)  $Q_1 = Q_2 + Q_3$  and  $V = V_1 + V_2$   
 (d)  $Q_2 = Q_3$  and  $V_2 = V_3$
14.  $A$ ,  $B$ ,  $C$  and  $D$  are large conducting plates kept parallel to each other.  $A$  and  $D$  are fixed. Plates  $B$  and  $C$ , connected to each other by a rigid conducting rod, can slide over frictionless rails as shown. Initially the distance between plates  $A$  and  $B$  is the same as that between plates  $C$  and  $D$ . If now the rod (along with plates  $B$  and  $C$ ) is slightly moved towards right, the capacitance between the terminals 1 and 2.



- (a) remains unchanged (b) increases  
 (c) decreases (d) nothing can be said

## Answers Key

### Subjective Type

1.  $13\text{ }\mu\text{F}$

### Single Correct Answer Type

2. (d) 3. (a) 4. (d) 5. (d) 6. (a)  
 7. (b) 8. (b) 9. (d) 10. (c) 11. (c)  
 12. (d) 13. (c) 14. (a)



# DPP 4.3

## Series and Parallel Combination of Capacitors 2

### Single Correct Answer Type

1. Four plates of equal area  $A$  are separated by equal distances  $d$  and are arranged as shown in the figure. The equivalent capacity is



(a)  $\frac{2\epsilon_0 A}{d}$  (b)  $\frac{3\epsilon_0 A}{d}$  (c)  $\frac{3\epsilon_0 A}{2d}$  (d)  $\frac{\epsilon_0 A}{d}$

2. The capacities of two conductors are  $C_1$  and  $C_2$  and their respective potentials are  $V_1$  and  $V_2$ . If they are connected by a thin wire, then the loss of energy will be given by

(a)  $\frac{C_1 C_2 (V_1 + V_2)}{2(C_1 + C_2)}$  (b)  $\frac{C_1 C_2 (V_1 - V_2)}{2(C_1 + C_2)}$   
 (c)  $\frac{C_1 C_2 (V_1 - V_2)^2}{2(C_1 + C_2)}$  (d)  $\frac{(C_1 + C_2)(V_1 - V_2)}{C_1 C_2}$

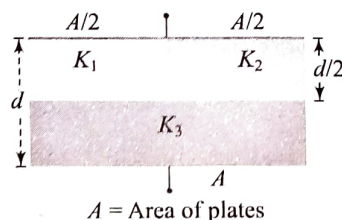
3. Two identical parallel plate capacitors are connected in series to a battery of 100 V. A dielectric slab of dielectric constant 4.0 is inserted between the plates of second capacitor. The potential difference across the capacitors will now be respectively

(a) 50 V, 50 V (b) 80 V, 20 V  
 (c) 20 V, 80 V (d) 75 V, 25 V

4. The equivalent capacitance of three capacitors of capacitance  $C_1$ ,  $C_2$  and  $C_3$  are connected in parallel is 12 units and product  $C_1 \cdot C_2 \cdot C_3 = 48$ . When the capacitors  $C_1$  and  $C_2$  are connected in parallel, the equivalent capacitance is 6 units. Then the capacitance are

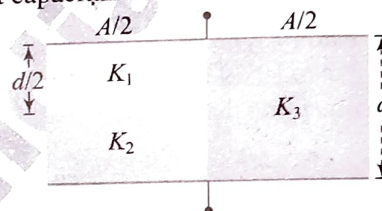
(a) 2, 3, 7 (b) 1.5, 2.5, 8  
 (c) 1, 5, 6 (d) 4, 2, 6

5. A parallel plate capacitor of area  $A$ , plate separation  $d$  and capacitance  $C$  is filled with three different dielectric materials having dielectric constants  $k_1$ ,  $k_2$  and  $k_3$  as shown. If a single dielectric material is to be used to have the same capacitance  $C$  in this capacitor, then its dielectric constant  $k$  is given by



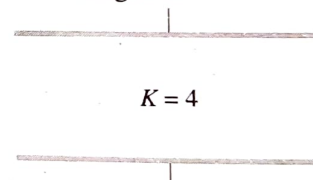
(a)  $\frac{1}{k} = \frac{1}{k_1} + \frac{1}{k_2} + \frac{1}{2k_3}$  (b)  $\frac{1}{k} = \frac{1}{k_1 + k_2} + \frac{1}{2k_3}$   
 (c)  $k = \frac{k_1 k_2}{k_1 + k_2} + 2k_3$  (d)  $k = k_1 + k_2 + 2k_3$

6. In the figure, a capacitor is filled with dielectrics. The resultant capacitance is



(a)  $\frac{2\epsilon_0 A}{d} \left[ \frac{1}{k_1} + \frac{1}{k_2} + \frac{1}{k_3} \right]$  (b)  $\frac{\epsilon_0 A}{d} \left[ \frac{1}{k_1} + \frac{1}{k_2} + \frac{1}{k_3} \right]$   
 (c)  $\frac{2\epsilon_0 A}{d} [k_1 + k_2 + k_3]$  (d) None of these

7. Consider a parallel plate capacitor of  $10 \mu\text{F}$  (micro-farad) with air filled in the gap between the plates. Now one-half of the space between the plates is filled with a dielectric of dielectric constant 4, as shown in the figure. The capacity of the capacitor changes to

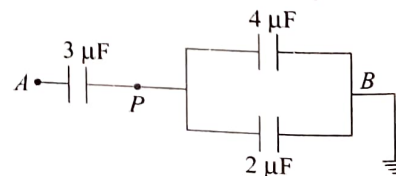


(a)  $25 \mu\text{F}$  (b)  $20 \mu\text{F}$  (c)  $40 \mu\text{F}$  (d)  $5 \mu\text{F}$

8. Three capacitors each of capacity  $4 \mu\text{F}$  are to be connected in such a way that the effective capacitance is  $6 \mu\text{F}$ . This can be done by

- (a) connecting them in parallel  
 (b) connecting two in series and one in parallel  
 (c) connecting two in parallel and one in series  
 (d) connecting all of them in series

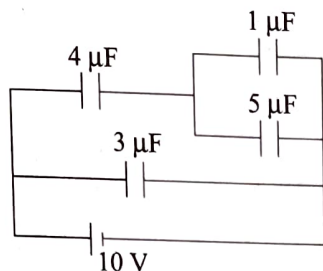
9. In the figure, a potential of  $+1200 \text{ V}$  is given to point A and point B is earthed, what is the potential at the point P



(a) 100 V (b) 200 V (c) 400 V (d) 600 V

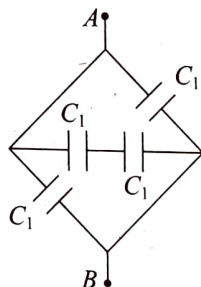
10. The charge on  $4\ \mu\text{F}$  capacitor in the given circuit is .... in  $\mu\text{C}$

- (a) 12 (b) 24 (c) 36 (d) 32

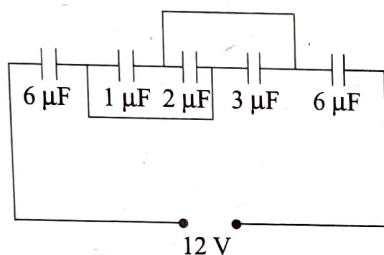


11. Four identical capacitors are connected as shown in the diagram. When a battery of 6 V is connected between A and B, the charge stored is found to be  $1.5\ \mu\text{C}$ . The value of  $C_1$  is

- (a)  $2.5\ \mu\text{F}$  (b)  $15\ \mu\text{F}$   
(c)  $1.5\ \mu\text{F}$  (d)  $0.1\ \mu\text{F}$

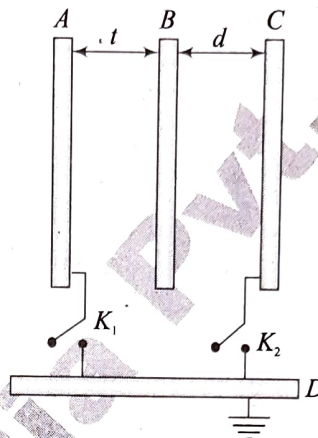


12. Figure shows five capacitors connected across a 12 V power supply. What is the charge on the  $2\ \mu\text{F}$  capacitor?



- (a)  $6\ \mu\text{C}$  (b)  $8\ \mu\text{C}$  (c)  $10\ \mu\text{C}$  (d)  $12\ \mu\text{C}$

13. Three plates A, B and C are placed close to each other with  $+Q$  charge given to the middle plate. The inner surfaces of A and C can be connected to earth through plate D and keys  $K_1$  and  $K_2$ . The plates D is a dielectric slab with dielectric constant  $K$ , then the charge that will flow through plate D when  $K_1$  is closed and  $K_2$  is open is



- (a)  $-Q$  (b)  $-Q/2$   
(c)  $Q\left(1 - \frac{1}{K}\right)$  (d)  $\frac{Q}{2}\left(1 - \frac{1}{K}\right)$

14. In the previous problem, when both the keys are closed, charge that will flow through key  $K_1$  will be:

- (a)  $\frac{t}{(d+t)}Q$  (b)  $\frac{d}{(d+t)}Q$   
(c)  $\frac{(d+t)}{t}Q$  (d)  $\frac{(d+t)}{d}Q$

## Answers Key

### Single Correct Answer Type

1. (a) 2. (c) 3. (b) 4. (d) 5. (b)

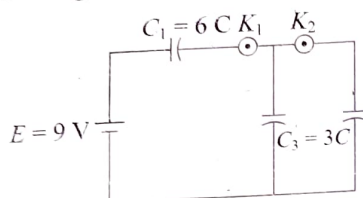
6. (d) 7. (a) 8. (b) 9. (c) 10. (b)  
11. (d) 12. (b) 13. (a) 14. (b)



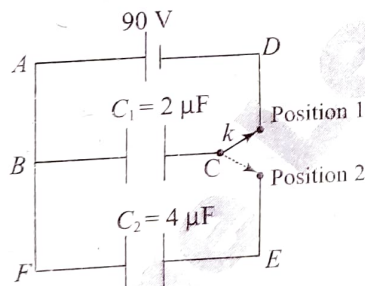
## Capacitors in a Circuit and Redistribution of Charge

### Subjective Type

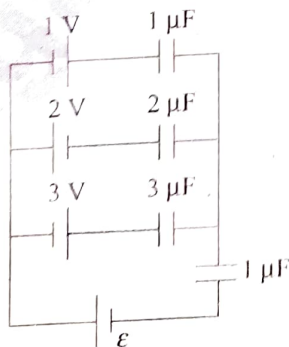
1. In the circuit shown in the figure, initially  $K_1$  is closed and  $K_2$  is open. What are the charges on each capacitors? Now  $K_1$  was opened and  $K_2$  was closed (order is important), what will be the charge on each capacitor now? [ $C = 1 \mu\text{F}$ ]



2. Figure shows two capacitors of capacitance  $2 \mu\text{F}$  and  $4 \mu\text{F}$  and a cell of  $90 \text{ V}$ . The switch 'k' is such that when it is in position 1, the circuit  $ABCD$  is closed and when it is in position 2, the circuit  $BCEF$  is closed. The resistance of both the circuits is negligible so that the capacitor gets fully charged instantly. Initially the switch is in position 1. Then it is turned in position 2. This makes one cycle. It is then again turned in position 1 and then in position 2. Now two cycles are completed. Find the charge (in  $\mu\text{C}$ ) on the capacitor of capacitance  $4 \mu\text{F}$  after two cycles.



3. In the figure shown, find the e.m.f.  $\mathcal{E}$  for which charge on  $2 \mu\text{F}$  capacitor is  $4 \mu\text{C}$ .



### Single Correct Answer Type

4. A condenser having a capacity of  $6 \mu\text{F}$  is charged to  $100 \text{ V}$  and is then joined to an uncharged condenser of  $14 \mu\text{F}$  and then removed. The ratio of the charges on  $6 \mu\text{F}$  and  $14 \mu\text{F}$  and the potential of  $6 \mu\text{F}$  will be

- (a)  $\frac{6}{14}$  and  $50 \text{ volt}$       (b)  $\frac{14}{6}$  and  $30 \text{ volt}$   
(c)  $\frac{6}{14}$  and  $30 \text{ volt}$       (d)  $\frac{14}{6}$  and  $0 \text{ volt}$

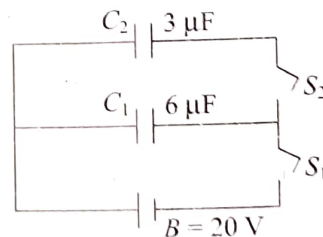
5. A capacitor  $4 \mu\text{F}$  charged to  $50 \text{ V}$  is connected to another capacitor of  $2 \mu\text{F}$  charged to  $100 \text{ V}$  with plates of like charges connected together. The total energy before and after connection in multiples of  $(10^{-2} \text{ J})$  is

- (a)  $1.5$  and  $1.33$       (b)  $1.33$  and  $1.5$   
(c)  $3.0$  and  $2.67$       (d)  $2.67$  and  $3.0$

6. A condenser of capacity  $C_1$  is charged to a potential  $V_0$ . The electrostatic energy stored in it is  $U_0$ . It is connected to another uncharged condenser of capacity  $C_2$  in parallel. The energy dissipated in the process is

- (a)  $\frac{C_2}{C_1 + C_2} U_0$       (b)  $\frac{C_1}{C_1 + C_2} U_0$   
(c)  $\left( \frac{C_1 - C_2}{C_1 + C_2} \right) U_0$       (d)  $\frac{C_1 C_2}{2(C_1 + C_2)} U_0$

7. In the circuit shown here  $C_1 = 6 \mu\text{F}$ ,  $C_2 = 3 \mu\text{F}$  and battery  $B = 20 \text{ V}$ . The switch  $S_1$  is first closed. It is then opened and afterwards  $S_2$  is closed. What is the charge finally on  $C_2$ ?



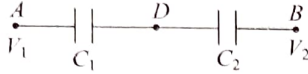
- (a)  $120 \mu\text{C}$       (b)  $80 \mu\text{C}$   
(c)  $40 \mu\text{C}$       (d)  $20 \mu\text{C}$

8. A  $10 \mu\text{F}$  capacitor and a  $20 \mu\text{F}$  capacitor are connected in series across a  $200 \text{ V}$  supply line. The charged capacitors are then disconnected from the line and reconnected with their positive plates together and negative plates together

and no external voltage is applied. What is the potential difference across each capacitor?

- (a)  $\frac{400}{9}$  V (b)  $\frac{800}{9}$  V  
(c) 400 V (d) 200 V

9. Two condensers  $C_1$  and  $C_2$  in a circuit are joined as shown in the figure. The potential of point A is  $V_1$  and that of B is  $V_2$ . The potential of point D will be

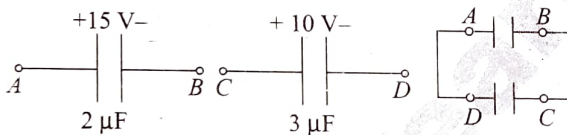


- (a)  $\frac{1}{2}(V_1 + V_2)$  (b)  $\frac{C_2 V_1 + C_1 V_2}{C_1 + C_2}$   
(c)  $\frac{C_1 V_1 + C_2 V_2}{C_1 + C_2}$  (d)  $\frac{C_2 V_1 - C_1 V_2}{C_1 + C_2}$

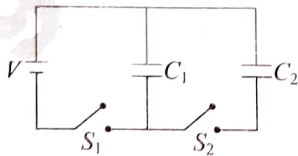
10. Two identical capacitors have the same capacitance  $C$ . One of them is charged to potential  $V_1$  and the other to  $V_2$ . The negative ends of the capacitors are connected together. When the positive ends are also connected, the decrease in energy of the combined system is

- (a)  $\frac{1}{4}C(V_1^2 - V_2^2)$  (b)  $\frac{1}{4}C(V_1^2 + V_2^2)$   
(c)  $\frac{1}{4}C(V_1 - V_2)^2$  (d)  $\frac{1}{4}C(V_1 + V_2)^2$

11. In the figure, initial status of capacitance and their connection is shown. Which of the following is incorrect about this circuit?



- (a) Final charge on each capacitor will be zero  
(b) Final total electrical energy of the capacitors will be zero  
(c) Total charge flown from A to D is  $30 \mu\text{C}$   
(d) Total charge flown from A to D is  $-30 \mu\text{C}$
12. Consider the circuit shown where  $C_1 = 6 \mu\text{F}$ ,  $C_2 = 3 \mu\text{F}$  and  $V = 20$  V. Capacitor  $C_1$  is first charged by closing the switch  $S_1$ . Switch  $S_1$  is then opened, and the charged capacitor is connected to the uncharged capacitor  $C_2$  by closing  $S_2$ .



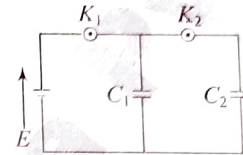
- (a) Total charge that has flown through the battery is  $120 \mu\text{C}$ .  
(b) Final charge on  $C_1$  after opening switch  $S_1$  and closing switch  $S_2$  is  $80 \mu\text{C}$ .

- (c) Final charge on  $C_2$  after opening switch  $S_1$  and closing switch  $S_2$  is  $40 \mu\text{C}$ .  
(d) Total heat produced after closing switch  $S_2$  is  $1.8 \text{ mJ}$ .

### Multiple Correct Answers Type

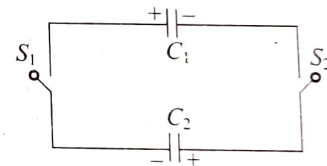
13. In the circuit shown in the figure initially key  $K_1$  is closed and key  $K_2$  is open. Then  $K_1$  is opened and  $K_2$  is closed (order is important).

[Take  $Q'_1$  and  $Q'_2$  as charges on  $C_1$  and  $C_2$  and  $V_1$  and  $V_2$  as voltage respectively.]



Then,

- (a) charge on  $C_1$  gets redistributed such that  $V_1 = V_2$   
(b) charge on  $C_1$  gets redistributed such that  $Q'_1 = Q'_2$   
(c) charge on  $C_1$  gets redistributed such that  $C_1 V_1 + C_2 V_2 = C_1 E$   
(d) charge on  $C_1$  gets redistributed such that  $Q'_1 + Q'_2 = C_1 E$
14. Two capacitors  $C_1$  and  $C_2$  are charged to the same potential  $V$ , but with opposite polarity as shown in the figure. The switch  $S_1$  and  $S_2$  are then closed.

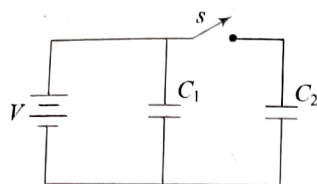


- (a) PDs across two capacitors are the same and is given by  $\frac{(C_1 - C_2)V}{(C_1 + C_2)}$   
(b) PDs across two capacitors are the same and is given by  $\frac{C_1 V}{(C_1 + C_2)}$   
(c) Ratio of final energy to initial energy of the system is  $\left(\frac{(C_1 - C_2)}{(C_1 + C_2)}\right)^2$   
(d) Ratio of final energy to initial energy of the system is  $\left(\frac{C_1}{(C_1 + C_2)^2}\right)$

15. Two capacitors of equal capacitance ( $C_1 = C_2$ ) are as shown in the figure. Initially, while the switch is open (as shown) one of the capacitors is uncharged and the other carries charge  $Q_0$ . The energy stored in the charged capacitor is  $U_0$ . Sometime after the switch is closed, the capacitors  $C_1$



and  $C_2$  carry charges  $Q_1$  and  $Q_2$  respectively; the energies stored in the capacitors are  $U_1$  and  $U_2$  respectively. Which of the following expression is correct?



(a)  $Q_0 = \frac{1}{2}(Q_1 + Q_2)$       (b)  $U_0 = U_1 + U_2$

(c)  $Q_0 = \frac{1}{2}\left(\frac{U_1}{Q_1} + \frac{U_2}{Q_2}\right)$       (d)  $Q_1 = Q_2$

## Answers Key

### Subjective Type

1. Case I:  $Q_1 = 18 \mu\text{C}$ ,  $Q_2 = 9 \mu\text{C}$  and  $Q_3 = 0$

Case II:  $Q'_2 = \frac{9}{2} \mu\text{C}$ ,  $Q_3 = \frac{9}{2} \mu\text{C}$

2.  $200 \mu\text{C}$

3.  $\varepsilon = 6 \text{ V}$  or  $\varepsilon = 34 \text{ V}$

### Single Correct Answer Type

4. (c)      5. (a)      6. (a)      7. (c)      8. (b)  
9. (c)      10. (c)      11. (c)      12. (a, b, c)

### Multiple Correct Answers Type

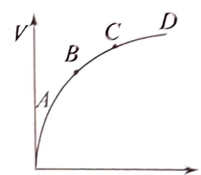
13. (a, c, d)      14. (a, c)      15. (a, d)

## DPP 5.1

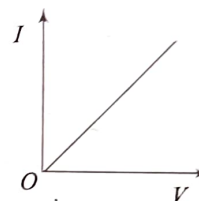
### Resistivity and Drift Velocity 1

#### Subjective Type

1. Is the motion of a charge across junction momentum conserving? Why or why not?
2. The relaxation time  $\tau$  is nearly independent of applied  $E$  field, whereas it changes significantly with temperature  $T$ . First fact is (in part) responsible for Ohm's law, whereas the second fact leads to variation of  $\rho$  with temperature. Elaborate why?

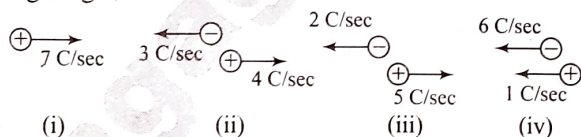


5.  $I$ - $V$  characteristic of a copper wire of length  $L$  and area of cross-section  $A$  is shown in the figure. The slope of the curve becomes



#### Single Correct Answer Type

3. Following figures show four situations in which positive and negative charges move horizontally through a region and give the rate at which each charge moves. Rank the situations according to the effective current through the region greatest first



- (a)  $i = ii = iii = iv$       (b)  $i > ii > iii > iv$   
 (c)  $i = ii = iii > iv$       (d)  $i = ii = iii < iv$

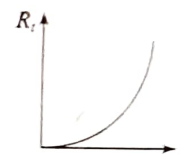
4. Variation of current passing through a conductor as the voltage applied across its ends as varied is shown in the adjoining diagram. If the resistance ( $R$ ) is determined at the points A, B, C and D, we will find that

- (a)  $R_C = R_D$       (b)  $R_B > R_A$   
 (c)  $R_C > R_B$       (d) None of these

- (a) More if the experiment is performed at higher temperature  
 (b) More if a wire of steel of the same dimension is used  
 (c) More if the length of the wire is increased  
 (d) Less if the length of the wire is increased

6. The resistance  $R_t$  of a conductor varies with temperature  $t$  as shown in the figure. If the variation is represented by  $R_t = R_0[1 + \alpha t + \beta t^2]$ , then

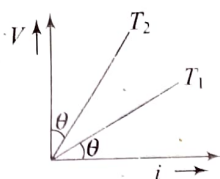
- (a)  $\alpha$  and  $\beta$  are both negative  
 (b)  $\alpha$  and  $\beta$  are both positive  
 (c)  $\alpha$  is positive and  $\beta$  is negative  
 (d)  $\alpha$  is negative and  $\alpha$  are positive



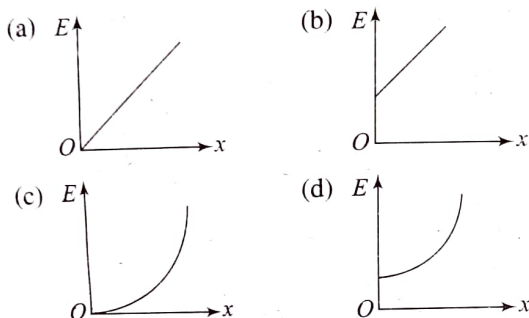


## 5.2 Electrostatics and Current Electricity

7. The  $V$ - $i$  graph for a conductor at temperature  $T_1$  and  $T_2$  are as shown in the figure. ( $T_2 - T_1$ ) is proportional to



- (a)  $\cos 2\theta$  (b)  $\sin \theta$   
(c)  $\cot 2\theta$  (d)  $\tan \theta$
8. A cylindrical conductor has uniform cross-section. Resistivity of its material increases linearly from the left end to the right end. If a constant current is flowing through it and at a section distance  $x$  from left end, magnitude of electric field intensity is  $E$ , which of the following graphs is correct



9. Dimensions of a block are  $1 \text{ cm} \times 1 \text{ cm} \times 100 \text{ cm}$ . If specific resistance of its material is  $3 \times 10^{-7} \text{ ohm-m}$ , then the resistance between the opposite rectangular faces is  
(a)  $3 \times 10^{-9} \Omega$  (b)  $3 \times 10^{-7} \Omega$   
(c)  $3 \times 10^{-5} \Omega$  (d)  $3 \times 10^{-3} \Omega$
10. In the above question, the resistance between the square faces is  
(a)  $3 \times 10^{-9} \Omega$  (b)  $3 \times 10^{-7} \Omega$   
(c)  $3 \times 10^{-5} \Omega$  (d)  $3 \times 10^{-3} \Omega$

11. A steady current flows in a metallic conductor of non-uniform cross-section. The quantity/quantities constant along the length of the conductor is/are  
(a) Current, electric field and drift speed  
(b) Drift speed only  
(c) Current and drift speed  
(d) Current only
12. A current  $I$  is passing through a wire having two sections  $P$  and  $Q$  of uniform diameters  $d$  and  $d/2$  respectively. If the mean drift velocity of electrons in sections  $P$  and  $Q$  is denoted by  $v_P$  and  $v_Q$  respectively, then  
(a)  $v_P = v_Q$  (b)  $v_P = \frac{1}{2} v_Q$   
(c)  $v_P = \frac{1}{4} v_Q$  (d)  $v_P = 2v_Q$
13. The length of the resistance wire is increased by 10%. What is the corresponding change in the resistance of wire?  
(a) 10% (b) 25% (c) 21% (d) 9%
14. Which of the following characteristics of electrons determines the current in a conductor?  
(a) Drift velocity alone  
(b) Thermal velocity alone  
(c) Both drift velocity and thermal velocity  
(d) Neither drift nor thermal velocity

### Multiple Correct Answers Type

15. Temperature dependence of resistivity  $\rho(T)$  of semiconductors, insulators and metals is significantly based on the following factors  
(a) number of charge carriers can change with temperature  $T$   
(b) time interval between two successive collisions can depend on  $T$   
(c) length of material can be a function of  $T$   
(d) mass of carriers is a function of  $T$

## Answers Key

### Subjective Type

1. no

### Single Correct Answer Type

3. (c) 4. (d) 5. (d) 6. (b) 7. (c)

8. (b) 9. (b) 10. (d) 11. (d) 12. (c)  
13. (c) 14. (a)

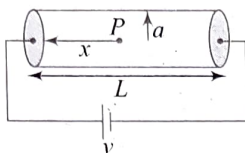
### Multiple Correct Answers Type

15. (a, b)

## Resistivity and Drift Velocity 2

### Subjective Type

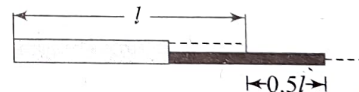
- A cylindrical solid of length  $L$  and radius  $a$  is connected across a source of emf  $V$  and negligible internal resistance shown in figure. The resistivity of the rod at point  $P$  at a distance  $x$  from left end is given by  $\rho = bx$  (where  $b$  is a positive constant). Find the electric field at point  $P$ .
- A common flashlight bulb is rated 0.30 A and 2.7 V (the values of the current and voltage under operating conditions). If the resistance of the tungsten bulb filament at room temperature  $20^\circ\text{C}$  is  $1.0\ \Omega$  and its temperature coefficient of resistivity is  $4.0 \times 10^{-3}^\circ\text{C}^{-1}$ , then find the temperature in centigrade of the filament when the bulb is on. (Consider the variation of resistance to be linear with temperature.)



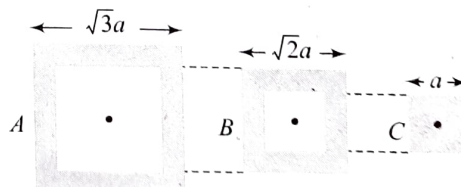
### Single Correct Answer Type

- Two wires of resistance  $R_1$  and  $R_2$  have temperature coefficient of resistance  $\alpha_1$  and  $\alpha_2$ , respectively. These are joined in series. The effective temperature coefficient of resistance is
  - $\frac{\alpha_1 + \alpha_2}{2}$
  - $\sqrt{\alpha_1 \alpha_2}$
  - $\frac{\alpha_1 R_1 + \alpha_2 R_2}{R_1 + R_2}$
  - $\frac{\sqrt{R_1 R_2 \alpha_1 \alpha_2}}{\sqrt{R_1^2 + R_2^2}}$
- Two resistances  $R_1$  and  $R_2$  are made of different materials. The temperature coefficient of the material of  $R_1$  is  $\alpha$  and of the material of  $R_2$  is  $-\beta$ . The resistance of the series combination of  $R_1$  and  $R_2$  will not change with temperature, if  $R_1/R_2$  equals
  - $\frac{\alpha}{\beta}$
  - $\frac{\alpha + \beta}{\alpha - \beta}$
  - $\frac{\alpha^2 + \beta^2}{\alpha\beta}$
  - $\frac{\beta}{\alpha}$
- An ionization chamber with parallel conducting plates as anode and cathode has  $5 \times 10^7$  electrons and the same number of singly-charged positive ions per  $\text{cm}^3$ . The electrons are moving at 0.4 m/s. The current density from anode to cathode is  $4\ \mu\text{A}/\text{m}^2$ . The velocity of positive ions moving towards cathode is

- 0.4 m/s
  - 16 m/s
  - Zero
  - 0.1 m/s
- The current in a conductor varies with time  $t$  as  $I = 2t + 3t^2$  where  $I$  is in ampere and  $t$  in seconds. Electric charge flowing through a section of the conductor during  $t = 2$  sec to  $t = 3$  sec is
    - 10C
    - 24C
    - 33C
    - 44C
  - The resistance of a wire of iron is 10 ohms and temp. coefficient of resistivity is  $5 \times 10^{-3}/^\circ\text{C}$ . At  $20^\circ\text{C}$  it carries 30 milliamperes of current. Keeping constant potential difference between its ends, the temperature of the wire is raised to  $120^\circ\text{C}$ . The current in milliamperes that flows in the wire is
    - 20
    - 15
    - 10
    - 40
  - Length of a hollow tube is 5 m, its outer diameter is 10 cm and thickness of its wall is 5 mm. If resistivity of the material of the tube is  $1.7 \times 10^{-8}\ \Omega \times \text{m}$  then resistance of tube will be
    - $5.6 \times 10^{-5}\ \Omega$
    - $2 \times 10^{-5}\ \Omega$
    - $4 \times 10^{-5}\ \Omega$
    - None of these
  - In order to quadruple the resistance of a uniform wire, a part of its length was uniformly stretched till the final length of the entire wire was 1.5 times the original length, the part of the wire was fraction equal to
    - 1/8
    - 1/6
    - 1/10
    - 1/4



- Following figure shows cross-sections through three long conductors of the same length and material, with square cross-section of edge lengths as shown. Conductor B will fit snugly within conductor A, and conductor C will fit snugly within conductor B. Relationship between their end to end resistance is

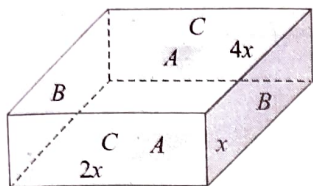


- $R_A = R_B = R_C$
- $R_A > R_B > R_C$
- $R_A < R_B < R_C$
- Information is not sufficient

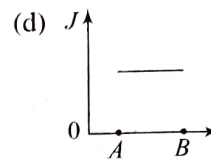
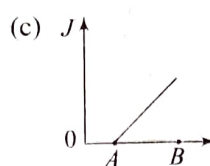
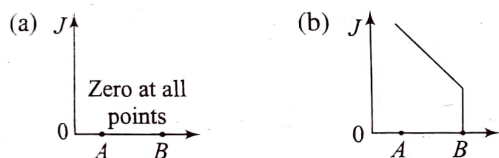
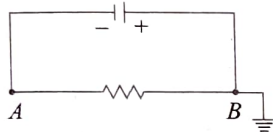


## 5.4 Electrostatics and Current Electricity

11. The following figure shows a rectangular block with dimensions  $x$ ,  $2x$  and  $4x$ . Electrical contacts can be made to the block between opposite pairs of faces (for example, between the faces labelled A-A, B-B and C-C). Between which two faces would the maximum electrical resistance be obtained (A-A: Top and bottom faces, B-B: Left and right faces, C-C: Front and rear faces)



- (a) A-A (b) B-B  
(c) C-C (d) Same for all three pairs
12. A battery is connected to a uniform resistance wire AB and B is earthed. Which one of the graphs below shows how the current density  $J$  varies along AB?



13. Two wires each of radius of cross section  $r$  but of different materials are connected together end to end (i.e. in series). If the densities of charge carriers in the two wires are in the ratio 1:4, the drift velocity of electrons in the two wires will be in the ratio:  
(a) 1 : 2 (b) 2 : 1 (c) 4 : 1 (d) 1 : 4
14. A solid conductor has a cross-section area  $1 \text{ cm}^2$  and  $2 \text{ cm}^2$  as shown in the figure. A current of  $20 \text{ A}$  entering at A. Then:



- (a) current density at A = current density at B  
(b) current density at A > current density at B  
(c) current density at A < current density at B  
(d) none of the above
15. A  $150 \text{ m}$  long metal wire connects points A and B. The electric potential at point B is  $50 \text{ V}$  less than that at point A. If the conductivity of the metal is  $60 \times 10^6 \text{ mho/m}$  then magnitude of the current density in the wire is equal to:  
(a)  $11 \times 10^{-4} \text{ A/m}^2$  (b)  $5.5 \times 10^{-3} \text{ A/m}^2$   
(c)  $4 \times 10^7 \text{ A/m}^2$  (d)  $20 \times 10^6 \text{ A/m}^2$

## Answers Key

### Subjective Type

1.  $E = \frac{2V}{L^2} x$

2.  $2020^\circ\text{C}$

### Single Correct Answer Type

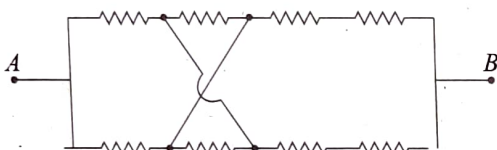
3. (c) 4. (d) 5. (d) 6. (b) 7. (a)  
8. (a) 9. (a) 10. (a) 11. (c) 12. (d)  
13. (c) 14. (b) 15. (d)

# DPP 5.3

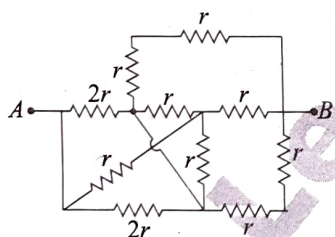
## Combination of Resistance 1

### Subjective Type

1. First a set of  $n$  equal resistors of  $R$  each are connected in series to a battery of emf  $E$  and internal resistance  $R$ . A current  $I$  is observed to flow. Then, the  $n$  resistors are connected in parallel to the same battery. It is observed that the current is increased 10 times. What is ' $n$ '?
2. Suppose there is a circuit consisting of only resistances and batteries. Suppose one is to double (or increase it to  $n$ -times) all voltages and all resistances. Show that currents are unaltered
3. Find the equivalent resistance between terminals  $A$  and  $B$ . Each resistor is of resistance  $R$ .

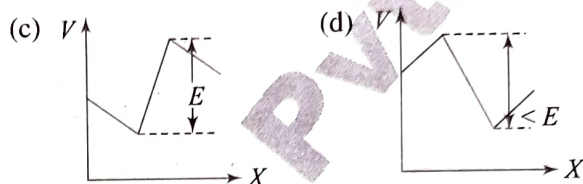
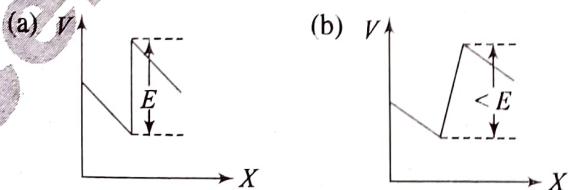


4. Find the equivalent resistance between  $A$  and  $B$  in the arrangement of resistances as shown.

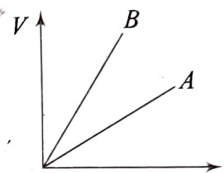


### Single Correct Answer Type

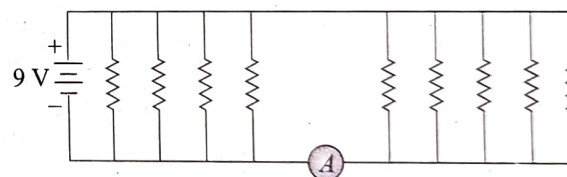
5. The two ends of a uniform conductor are joined to a cell of emf  $E$  and some internal resistances. Starting from the midpoint  $P$  of the conductor, we move in the direction of current and return to  $P$ . The potential  $V$  at every point on the path is plotted against the distance covered ( $x$ ). Which of the following graphs best represents the resulting curve?



6.  $V-i$  graphs for parallel and series combination of two identical resistors are as shown in the figure. Which graph represents parallel combination?



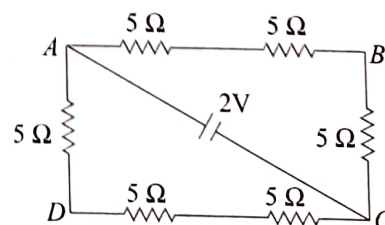
- (a) A
  - (b) B
  - (c) A and B both
  - (d) Neither A nor B
7. If each resistance in the figure is of  $9\ \Omega$ , then reading of ammeter is



- (a) 5 A
  - (b) 8 A
  - (c) 2 A
  - (d) 9 A
8. Two resistors of resistance  $R_1$  and  $R_2$  having  $R_1 > R_2$  are connected in parallel. For equivalent resistance  $R$ , the correct statement is

- (a)  $R > R_1 > R_2$
  - (b)  $R_1 < R < R_2$
  - (c)  $R_2 < R < (R_1 + R_2)$
  - (d)  $R < R_1$
9. The potential difference between points  $A$  and  $B$  of adjoining figure is

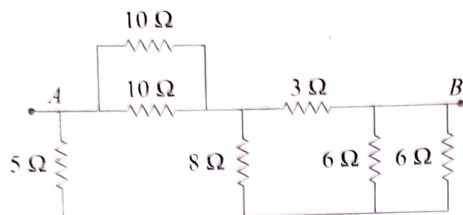
- (a)  $\frac{2}{3}\text{ V}$
- (b)  $\frac{8}{9}\text{ V}$
- (c)  $\frac{4}{3}\text{ V}$
- (d) 2 V





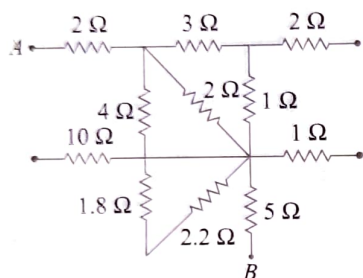
## 5.6 Electrostatics and Current Electricity

10. Seven resistances are connected as shown in the figure. The equivalent resistance between  $A$  and  $B$  is  
 (a)  $3\ \Omega$  (b)  $4\ \Omega$  (c)  $4.5\ \Omega$  (d)  $5\ \Omega$



11. What is the equivalent resistance between the points  $A$  and  $B$  of the network?

- (a)  $\frac{57}{7}\ \Omega$  (b)  $8\ \Omega$  (c)  $6\ \Omega$  (d)  $\frac{57}{5}\ \Omega$

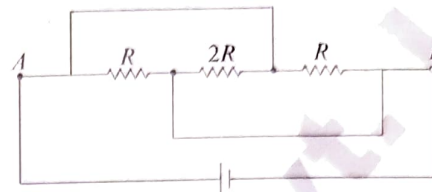


12. A uniform wire of resistance  $9\ \Omega$  is cut into 3 equal parts. They are connected in the form of equilateral triangle

$ABC$ . A cell of emf  $2\text{ V}$  and negligible internal resistance is connected across  $B$  and  $C$ . Potential difference across  $AB$  is

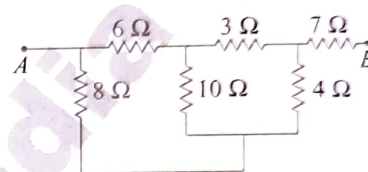
- (a)  $1\text{ V}$  (b)  $2\text{ V}$  (c)  $3\text{ V}$  (d)  $0.5\text{ V}$

13. In the figure shown the current flowing through  $2R$  is:



- (a) from left to right (b) from right to left  
 (c) no current (d) none of these

14. The equivalent resistance between the points  $A$  and  $B$  is:



- (a)  $\frac{36}{7}\ \Omega$  (b)  $10\ \Omega$   
 (c)  $\frac{85}{7}\ \Omega$  (d) none of these

## Answers Key

### Subjective Type

1. 10 3.  $\frac{3}{2R}$  4.  $r$

### Single Correct Answer Type

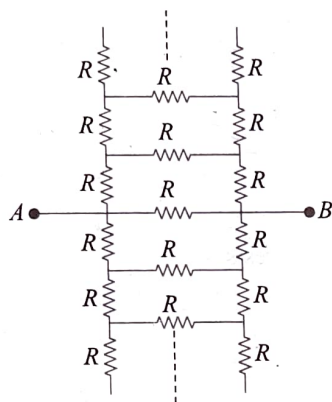
5. (b) 6. (a) 7. (a) 8. (d) 9. (c)  
 10. (b) 11. (b) 12. (a) 13. (b) 14. (c)

# DPP 5.4

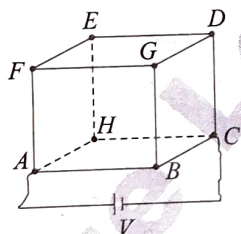
## Combination of Resistance 2

### Subjective Type

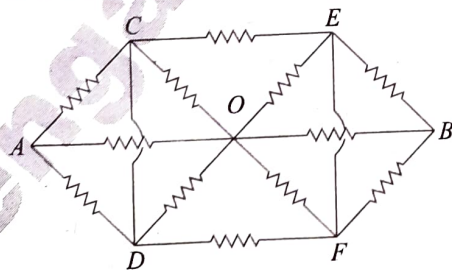
1. If each resistance  $R = 100\sqrt{3} \Omega$ , then find equivalent resistance (in ohm) between A and B.



2. In the figure shown eight resistors each of resistance ' $R$ ' are connected to form two squares  $ABCH$  and  $DEFG$ . Four resistors each of resistance ' $2R$ ' are connected in the vertical lines  $AF$ ,  $BG$ ,  $CD$  and  $EH$ . 'A' and 'C' are connected to a battery of internal resistance ' $R$ ' and emf  $V$ . Find out the current in ' $AB$ ' and ' $ED$ '.



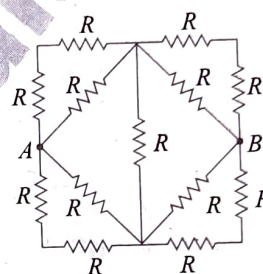
3. Find the equivalent resistance between A and B. Each resistor has the same resistance,  $R$ .



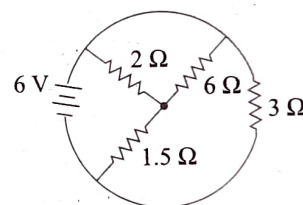
### Single Correct Answer Type

4. Thirteen resistances each of resistance  $R \Omega$  are connected in the circuit as shown in the following figure. The effective resistance between A and B is

- (a)  $2R \Omega$  (b)  $\frac{4R}{3} \Omega$  (c)  $\frac{2R}{3} \Omega$  (d)  $R \Omega$

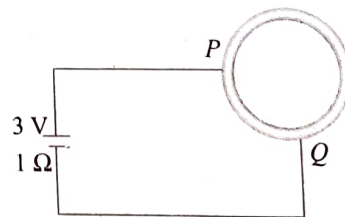


5. The total current supplied to the circuit by the battery is



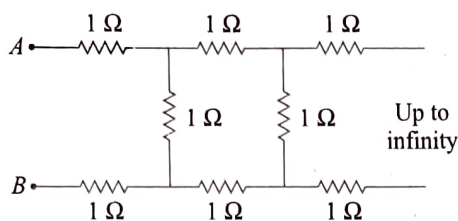
- (a) 1 A (b) 2 A (c) 4 A (d) 6 A
6. A wire of resistance  $10 \Omega$  is bent to form a circle. P and Q are points on the circumference of the circle dividing it into a quadrant and are connected to a battery of 3 V and internal resistance  $1 \Omega$  as shown in the figure. The currents in the two parts of the circle are:

- (a)  $\frac{6}{23} \text{ A}$  and  $\frac{18}{23} \text{ A}$  (b)  $\frac{5}{26} \text{ A}$  and  $\frac{15}{26} \text{ A}$   
 (c)  $\frac{4}{25} \text{ A}$  and  $\frac{12}{25} \text{ A}$  (d)  $\frac{3}{25} \text{ A}$  and  $\frac{9}{25} \text{ A}$





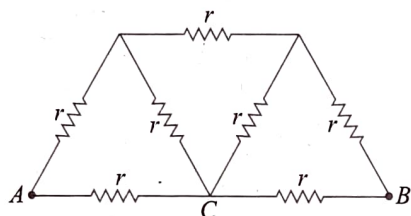
7. The resistance between the terminal points A and B of the given infinitely long circuit will be



- (a)  $(\sqrt{3} - 1)$  (b)  $(1 - \sqrt{3})$   
(c)  $(1 + \sqrt{3})$  (d)  $(2 + \sqrt{3})$

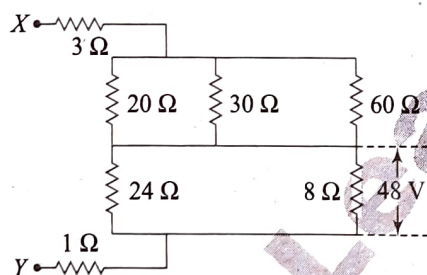
8. In the circuit shown, the value of each resistance is  $r$ , then equivalent resistance of circuit between points A and B will be

- (a)  $(4/3)r$  (b)  $3r/2$   
(c)  $r/3$  (d)  $8r/7$



9. The potential difference across 8 ohm resistance is 48 volt as shown in the figure. The value of potential difference across X and Y points will be

- (a) 160 volt (b) 128 volt  
(c) 80 volt (d) 62 volt

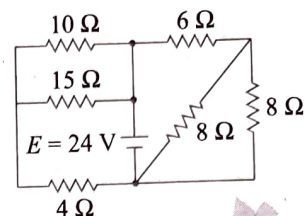


10. The resistance of the series combination of two resistance is  $S$ . When they are joined in parallel the total resistance is  $P$ . If  $S = nP$ , then the minimum possible value of  $n$  is

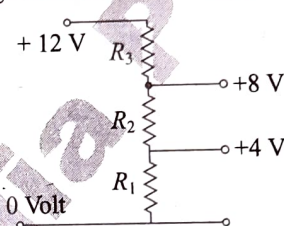
- (a) 4 (b) 3 (c) 2 (d) 1

11. Find the equivalent resistance across the terminals of source of e.m.f. 24 V for the circuit shown in figure

- (a) 15  $\Omega$  (b) 10  $\Omega$  (c) 5  $\Omega$  (d) 4  $\Omega$

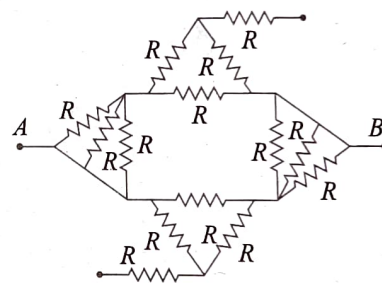


12. A potential divider is used to give outputs of 4 V and 8 V from a 12 V source. Which combination of resistances, ( $R_1, R_2, R_3$ ) gives the correct voltages?  $R_1 : R_2 : R_3$



- (a) 2 : 1 : 2 (b) 1 : 1 : 1  
(c) 2 : 2 : 1 (d) 1 : 1 : 2

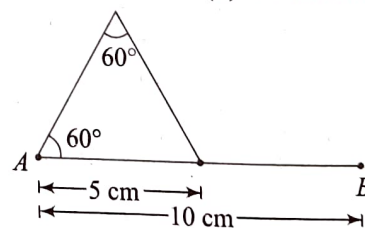
13. Find equivalent resistance between A and B



- (a)  $R$  (b)  $\frac{3R}{4}$  (c)  $\frac{R}{2}$  (d)  $2R$

14. A wire has resistance of 24  $\Omega$  is bent in the following shape. The effective resistance between A and B is

- (a) 24  $\Omega$  (b) 10  $\Omega$   
(c)  $\frac{16}{3} \Omega$  (d) None of these



## Answers Key

### Subjective Type

1. 100  $\Omega$  3.  $R_{eq} = \frac{4}{5}R$

### Single Correct Answer Type

4. (c) 5. (c) 6. (a) 7. (c) 8. (d)  
9. (a) 10. (a) 11. (c) 12. (b) 13. (c)  
14. (b)

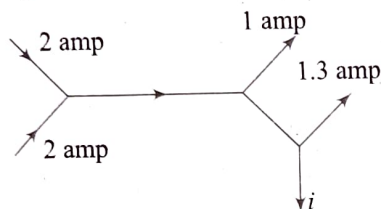
# DPP 5.5

## Kirchhoff's Law and Grouping of Cells

### Single Correct Answer Type

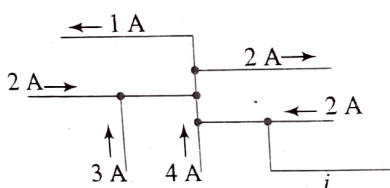
1. The figure below shows currents in a part of electric circuit. The current  $i$  is

(a) 1.7 amp (b) 3.7 amp  
(c) 1.3 amp (d) 1 amp



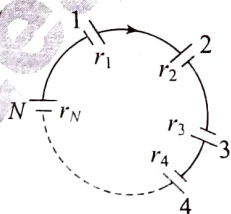
2. The figure here shows a portion of a circuit. What are the magnitude and direction of the current  $i$  in the lower right-hand wire?

(a) 7 A (b) 8 A (c) 6 A (d) 2 A



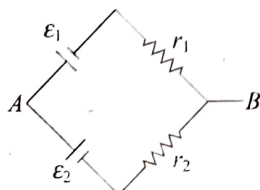
3. A group of  $N$  cells whose  $emf$  varies directly with the internal resistance as per the equation  $E_N = 1.5 r_N$  are connected as shown in the figure. The current  $I$  in the circuit is

(a) 0.51 amp  
(b) 5.1 amp  
(c) 0.15 amp  
(d) 1.5 amp



4. Two batteries of  $emf$   $\epsilon_1$  and  $\epsilon_2$  ( $\epsilon_2 > \epsilon_1$ ) and internal resistances  $r_1$  and  $r_2$  respectively are connected in parallel as shown in the figure.

(a) Two equivalent  $emf$   $\epsilon_{eq}$  of the two cells is between  $\epsilon_1$  and  $\epsilon_2$ , i.e.,  $\epsilon_1 < \epsilon_{eq} < \epsilon_2$   
(b) The equivalent  $emf$   $\epsilon_{eq}$  is smaller than  $\epsilon_1$   
(c) The  $\epsilon_{eq}$  is given by  $\epsilon_{eq} = \epsilon_1 + \epsilon_2$  always  
(d)  $\epsilon_{eq}$  is independent of internal resistances  $r_1$  and  $r_2$



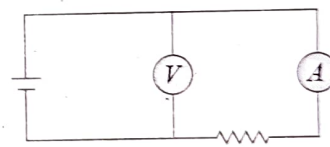
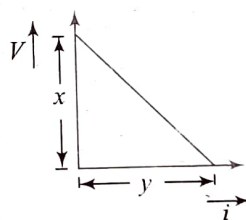
5. 12 cells each having same  $emf$  are connected in series with some cells wrongly connected. The arrangement is connected in series with an ammeter and two cells which are in series. Current is 3 A when cells and battery aid each other and is 2 A when cells and battery oppose each other. The number of cells wrongly connected is

(a) 4 (b) 1 (c) 3 (d) 2

6. A battery of 24 cells each of  $emf$  1.5 V and internal resistance  $2 \Omega$  is to be connected in order to send the maximum current through a  $12 \Omega$  resistor. The correct arrangement of cells will be

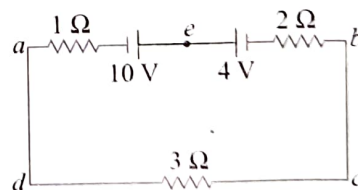
(a) 2 rows of 12 cells connected in parallel  
(b) 3 rows of 8 cells connected in parallel  
(c) 4 rows of 6 cells connected in parallel  
(d) All of these

7. In an experiment, a graph was plotted of the potential difference  $V$  between the terminals of a cell against the circuit current  $i$  by varying load rheostat. Internal conductance of the cell is given by



(a)  $xy$  (b)  $\frac{y}{x}$  (c)  $\frac{x}{y}$  (d)  $(x - y)$

8. The magnitude and direction of the current in the circuit shown will be

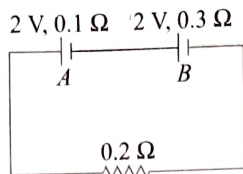


(a)  $\frac{7}{3}$  A from  $a$  to  $b$  through  $e$   
(b)  $\frac{7}{3}$  A from  $b$  to  $a$  through  $e$   
(c) 1 A from  $b$  to  $a$  through  $e$   
(d) 1 A from  $a$  to  $b$  through  $e$



### 5.10 Electrostatics and Current Electricity

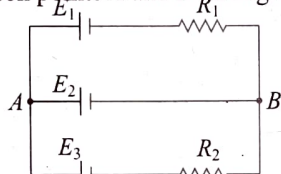
9. The internal resistances of two cells shown are  $0.1\ \Omega$  and  $0.3\ \Omega$ . If  $R = 0.2\ \Omega$ , the potential difference across the cell



- (a)  $B$  will be zero  
(b)  $A$  will be zero  
(c)  $A$  and  $B$  will be  $2\text{ V}$   
(d)  $A$  will be  $> 2\text{ V}$  and  $B$  will be  $< 2\text{ V}$
10. Two cells of equal *e.m.f.* and of internal resistances  $r_1$  and  $r_2$  ( $r_1 > r_2$ ) are connected in series. On connecting this combination to an external resistance  $R$ , it is observed that the potential difference across the first cell becomes zero. The value of  $R$  will be

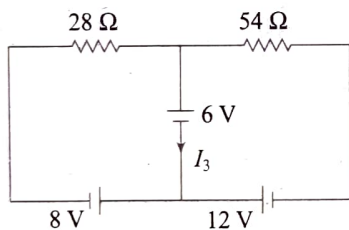
- (a)  $r_1 + r_2$  (b)  $r_1 - r_2$   
(c)  $\frac{r_1 + r_2}{2}$  (d)  $\frac{r_1 - r_2}{2}$

11. In the circuit shown here,  $E_1 = E_2 = E_3 = 2\text{ V}$  and  $R_1 = R_2 = 4\ \Omega$ . The current flowing between points  $A$  and  $B$  through battery  $E_2$  is



- (a) Zero  
(b)  $2\text{ A}$  from  $A$  to  $B$   
(c)  $2\text{ A}$  from  $B$  to  $A$   
(d) None of the above

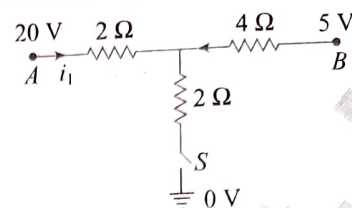
12. Consider the circuit shown in the figure. The current  $I_3$  is equal to



(a)  $5\text{ A}$

(b)  $3\text{ A}$

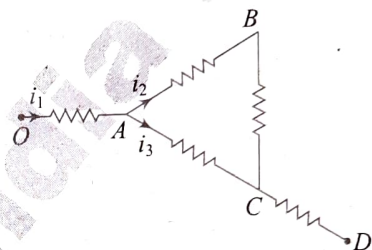
- (c)  $-3\text{ A}$  (d)  $-5/6\text{ A}$
13. As the switch  $S$  is closed in the circuit shown in figure, current passed through it is



- (a)  $4.5\text{ A}$  (b)  $6.0\text{ A}$  (c)  $3.0\text{ A}$  (d) Zero

### Multiple Correct Answers Type

14. The current in the arm  $CD$  of the circuit will be



- (a)  $i_1$  (b)  $i_2 + i_3$   
(c)  $i_1 + i_3$  (d)  $i_1 - i_2 + i_3$

15. Kirchhoff's junction rule is a reflection of

- (a) conservation of current density vector  
(b) conservation of charge  
(c) the fact that the momentum with which a charged particle approaches a junction is unchanged (as a vector) as the charged particle leaves the junction  
(d) the fact that there is no accumulation of charges at a junction

## Answers Key

### Single Correct Answer Type

1. (a) 2. (b) 3. (d) 4. (a) 5. (b)  
6. (a) 7. (b) 8. (d) 9. (a) 10. (b)  
11. (b) 12. (d) 13. (a)

### Multiple Correct Answers Type

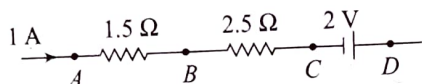
14. (a, b) 15. (b, d)

# DPP 5.6

## Kirchhoff's Law and Simple Circuits

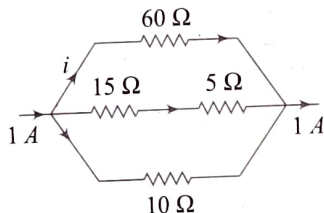
### Single Correct Answer Type

1. In the circuit element given here, if the potential at point B,  $V_B = 0$ , then the potentials of A and D are given as

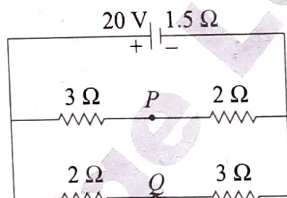


- (a)  $V_A = -1.5 \text{ V}$ ,  $V_D = +2 \text{ V}$   
 (b)  $V_A = +1.5 \text{ V}$ ,  $V_D = +2 \text{ V}$   
 (c)  $V_A = +1.5 \text{ V}$ ,  $V_D = +0.5 \text{ V}$   
 (d)  $V_A = +1.5 \text{ V}$ ,  $V_D = -0.5 \text{ V}$

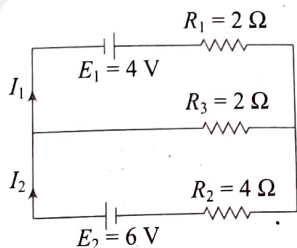
2. The magnitude of  $i$  in ampere unit is



- (a) 0.1 (b) 0.3  
 (c) 0.6 (d) None of these
3. If in the circuit shown below, the internal resistance of the battery is  $1.5 \Omega$  and  $V_P$  and  $V_Q$  are the potentials at P and Q respectively, what is the potential difference between the points P and Q



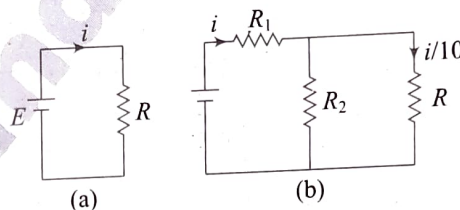
- (a) Zero (b) 4 volts ( $V_P > V_Q$ )  
 (c) 4 volts ( $V_Q > V_P$ ) (d) 2.5 volts ( $V_Q > V_P$ )
4. In the circuit shown below  $E_1 = 4.0 \text{ V}$ ,  $R_1 = 2 \Omega$ ,  $E_2 = 6.0 \text{ V}$ ,  $R_2 = 4 \Omega$  and  $R_3 = 2 \Omega$ . The current  $I_1$  is



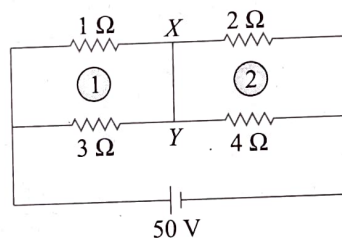
- (a) 1.6 A (b) 1.8 A  
 (c) 1.25 A (d) 1.0 A
5. Consider the circuits shown in the figure. Both the circuits are taking the same current from battery but current through  $R$  in the second circuit is  $\frac{1}{10}$ th of current through  $R$  in the

first circuit. If  $R$  is  $11 \Omega$ , the value of  $R_1$

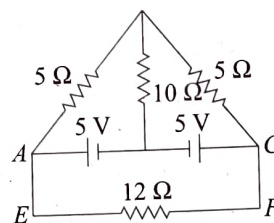
- (a)  $9.9 \Omega$  (b)  $11 \Omega$   
 (c)  $8.8 \Omega$  (d)  $7.7 \Omega$



6. Current through wire XY of circuit shown is
- (a) 1 A (b) 4 A  
 (c) 2 A (d) 3 A



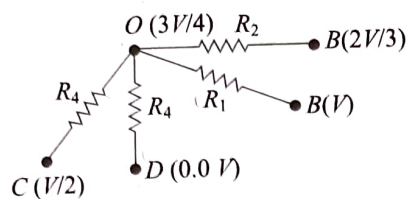
7. In the circuit of adjoining figure the current through  $12 \Omega$  resistor will be



- (a) 1 A (b)  $\frac{1}{5} \text{ A}$   
 (c)  $\frac{2}{5} \text{ A}$  (d) 0 A

8. The circuit is shown in the following figure. The potential at points A, B, C, D and O are given. The currents in the resistances  $R_1$ ,  $R_2$  and  $R_3$  are in the ratio of 4 : 2 : 1. What is the ratio of resistances  $R_1$ ,  $R_2$ ,  $R_3$  and  $R_4$ ?

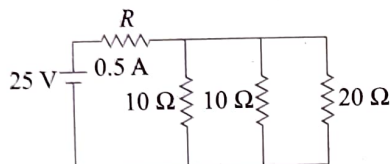




- (a) 3 : 2 : 12 : 16      (b) 2 : 3 : 36 : 12  
(c) 4 : 3 : 12 : 32      (d) 3 : 4 : 14 : 32

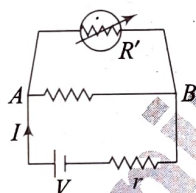
### Multiple Correct Answers Type

9. In the circuit as shown in figure if the current drawn through battery is 0.5 A. Then



- (a) Resistance  $R = 46 \Omega$   
(b) Current through  $20 \Omega$  resistance is 0.1 A  
(c) Potential difference across the middle resistance is 2 V  
(d) Potential difference across the  $20 \Omega$  resistance is 4 V

10. Consider a simple circuit shown in figure stands for a variable resistance  $R'$ .  $R'$  can vary from  $R_0$  to infinity,  $r$  is internal resistance of the battery ( $r \ll R \ll R'$ ).

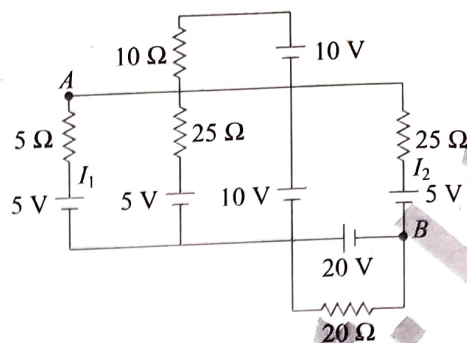


- (a) Potential drop across AB is nearly constant as  $R'$  is varied  
(b) Current through  $R'$  is nearly a constant as  $R'$  is varied  
(c) Current  $I$  depends sensitively on  $R'$   
(d)  $I \geq \frac{V}{r+R}$  always

### Comprehension Type

#### For Problems 11 and 12

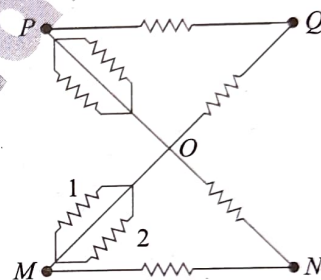
The circuit consists of resistors and ideal cells.  $I_1$  and  $I_2$  are current through branches indicated in the figure.  $V_A$  and  $V_B$  is the potential at points A and B on the circuit



11. The value of  $\frac{I_2}{I_1}$  is:  
(a) 1      (b) 2      (c) 3      (d) 4  
12. The value of  $V_A - V_B$  in volts is:  
(a) 5      (b) 10      (c) 15      (d) 30

#### For Problems 13–15

In the given circuit, if resistance of each resistor is  $R$ :



13. Find the equivalent resistance between M and N.  
(a)  $\frac{5}{2}R$       (b)  $5R$       (c)  $\frac{31}{10}R$       (d)  $\frac{3}{5}R$   
14. How much current will flow through resistor 1, if current entered at M is  $I$ :  
(a)  $\frac{I}{5}$       (b)  $\frac{2I}{5}$       (c)  $\frac{3I}{5}$       (d)  $\frac{4I}{5}$   
15. The equivalent resistance between M and Q  
(a)  $\frac{R}{2}$       (b)  $\frac{R}{3}$       (c)  $R$       (d)  $2R$

## Answers Key

### Single Correct Answer Type

1. (d)      2. (a)      3. (d)      4. (b)      5. (a)  
6. (c)      7. (d)      8. (a)

### Multiple Correct Answers Type

9. (a, b, c)      10. (a, d)

### Comprehension Type

11. (a)      12. (d)      13. (d)      14. (a)      15. (c)

# CHAPTER

# 6

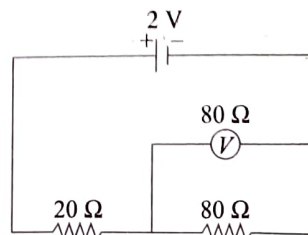
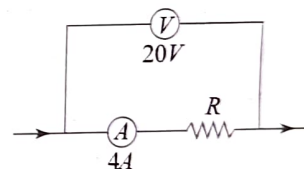
# Electrical Measuring Instruments

## DPP 6.1

### Ammeter and Voltmeter 1

#### Single Correct Answer Type

- 50  $\Omega$  and 100  $\Omega$  resistors are connected in series. This connection is connected with a battery of 2.4 V. When a voltmeter of 100  $\Omega$  resistance is connected across 100  $\Omega$  resistor, then the reading of the voltmeter will be  
(a) 1.6 V (b) 1.0 V  
(c) 1.2 V (d) 2.0 V
- An ammeter gives full-scale deflection when current of 1.0 A is passed in it. To convert it into 10 A range ammeter, the ratio of its resistance and the shunt resistance will be  
(a) 1 : 9 (b) 1 : 10  
(c) 1 : 11 (d) 9 : 1
- 100 mA current gives a full-scale deflection in a galvanometer of 2  $\Omega$  resistance. The resistance connected with the galvanometer to convert it into a voltmeter to measure 5 V is  
(a) 98  $\Omega$  (b) 52  $\Omega$   
(c) 50  $\Omega$  (d) 48  $\Omega$
- When a 12  $\Omega$  resistor is connected with a moving coil galvanometer, then its deflection reduces from 50 divisions to 10 divisions. The resistance of the galvanometer is  
(a) 24  $\Omega$  (b) 36  $\Omega$   
(c) 48  $\Omega$  (d) 60  $\Omega$
- The resistance of a galvanometer is 90  $\Omega$ . If only 10 percent of the main current may flow through the galvanometer, in which way and of what value, a resistor is to be used  
(a) 10  $\Omega$  in series (b) 10  $\Omega$  in parallel  
(c) 810  $\Omega$  in series (d) 810  $\Omega$  in parallel
- In the diagram shown, the reading of voltmeter is 20 V and that of ammeter is 4 A. The value of  $R$  should be (Consider given ammeter and voltmeter are not ideal)  
(a) Equal to 5  $\Omega$   
(b) Greater from 5  $\Omega$   
(c) Less than 5  $\Omega$   
(d) Greater or less than 5  $\Omega$  depends on the material of  $R$
- A voltmeter having a resistance of 998  $\Omega$  is connected to a cell of e.m.f. 2 volt and internal resistance 2  $\Omega$ . The error in the measurement of e.m.f. will be  
(a)  $4 \times 10^{-1}$  V (b)  $2 \times 10^{-3}$  V  
(c)  $4 \times 10^{-3}$  V (d)  $2 \times 10^{-1}$  V
- A 100 V voltmeter of internal resistance 20 k $\Omega$  in series with a high resistance  $R$  is connected to a 110 V line. The voltmeter reads 5 V, the value of  $R$  is  
(a) 210 k $\Omega$  (b) 315 k $\Omega$   
(c) 420 k $\Omega$  (d) 440 k $\Omega$
- In the adjoining circuit, the e.m.f. of the cell is 2 V and the internal resistance is negligible. The resistance of the voltmeter is 80  $\Omega$ . The reading of the voltmeter will be

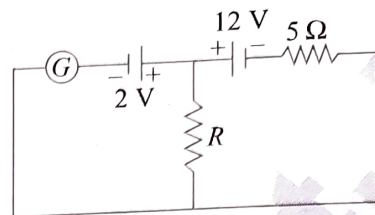




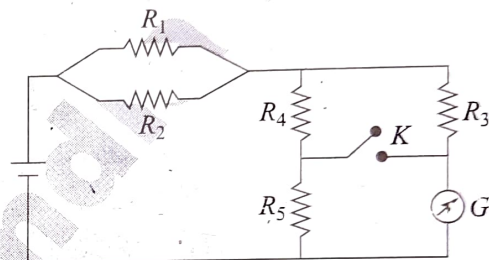
## 6.2 Electrostatics and Current Electricity

- (a) 0.80 V (b) 1.60 V  
(c) 1.33 V (d) 2.00 V
10. A galvanometer has 30 divisions and a sensitivity  $16 \mu\text{A}/\text{div}$ . It can be converted into a voltmeter to read 3 V by connecting  
(a) Resistance nearly  $6 \text{ k}\Omega$  in series  
(b)  $6 \text{ k}\Omega$  in parallel  
(c)  $500 \Omega$  in series  
(d) It cannot be converted
11. Voltmeters  $V_1$  and  $V_2$  are connected in series across a D.C. line.  $V_1$  reads 80 V and has a per volt resistance of  $200 \Omega$ .  $V_2$  has a total resistance of  $32 \text{ k}\Omega$ . The line voltage is  
(a) 120 V (b) 160 V  
(c) 220 V (d) 240 V
12. A voltmeter has a range  $0-V$  with a series resistance  $R$ . With a series resistance  $2R$ , the range is  $0-V'$ . The correct relation between  $V$  and  $V'$  is  
(a)  $V' = 2 V$  (b)  $V' > 2 V$   
(c)  $V' \gg 2 V$  (d)  $V' < 2 V$
13. A moving coil galvanometer is converted into an ammeter reading up to 0.03 A by connecting a shunt of resistance  $4r$  across it and into an ammeter reading up to 0.06 A when a shunt of resistance  $r$  is connected across it. What is the maximum current which can be sent through this galvanometer if no shunt is used?

- (a) 0.01 A (b) 0.02 A  
(c) 0.03 A (d) 0.04 A
14. In the circuit shown, the galvanometer shows zero current. The value of resistance  $R$  is:



- (a)  $1 \Omega$  (b)  $2 \Omega$   
(c)  $4 \Omega$  (d)  $9 \Omega$
15. Whether the switch  $K$  is open or closed, the reading of galvanometer is the same. If  $I$  denotes the current then:



- (a)  $IR_4 = I_G$  (b)  $IR_5 = I_G$   
(c)  $IR_3 = I_G$  (d)  $IR_4 = IR_3$

## Answers Key

### Single Correct Answer Type

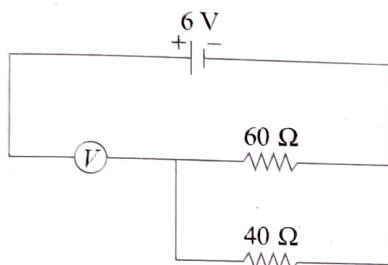
- |        |        |        |        |        |         |         |         |         |         |
|--------|--------|--------|--------|--------|---------|---------|---------|---------|---------|
| 1. (c) | 2. (d) | 3. (d) | 4. (c) | 5. (b) | 6. (c)  | 7. (c)  | 8. (c)  | 9. (c)  | 10. (a) |
|        |        |        |        |        | 11. (d) | 12. (d) | 13. (b) | 14. (a) | 15. (c) |

# DPP 6.2

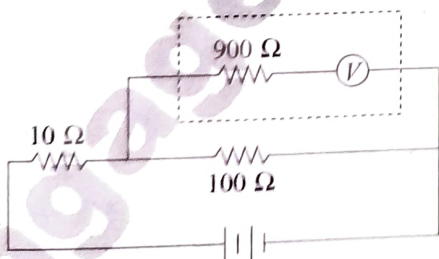
## Ammeter and Voltmeter 2

### Single Correct Answer Type

1. The measurement of voltmeter in the following circuit is

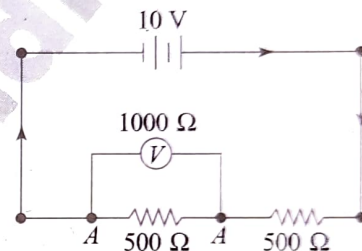


- (a) 2.4 V (b) 3.4 V  
(c) 4.0 V (d) 6.0 V
2. An ammeter and a voltmeter of resistance  $R$  are connected in series to an electric cell of negligible internal resistance. Their readings are  $A$  and  $V$  respectively. If another resistance  $R$  is connected in parallel with the voltmeter, then
- (a) both  $A$  and  $V$  will increase  
(b) both  $A$  and  $V$  will decrease  
(c)  $A$  will decrease and  $V$  will increase  
(d)  $A$  will increase and  $V$  will decrease
3. The potential difference across the  $100\ \Omega$  resistance in the following circuit is measured by a voltmeter of  $900\ \Omega$  resistance. The percentage error made in reading the potential difference is
- (a)  $\frac{10}{9}$  (b) 0.1  
(c) 1.0 (d) 10.0

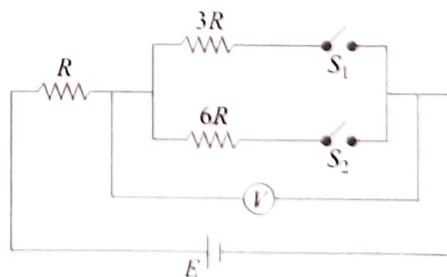


4. Two resistances of  $400\ \Omega$  and  $800\ \Omega$  are connected in series with 6 V battery of negligible internal resistance. A voltmeter of resistance  $10000\ \Omega$  is used to measure the potential difference across  $400\ \Omega$ . The error in the measurement of potential difference in volts approximately is
- (a) 0.01 (b) 0.02  
(c) 0.03 (d) 0.05

5. A galvanometer, having a resistance of  $50\ \Omega$ , gives a full-scale deflection for a current of  $0.05\ \text{A}$ . The length in meter of a resistance wire of area of cross-section  $2.97 \times 10^{-2}\ \text{cm}^2$  that can be used to convert the galvanometer into an ammeter which can read a maximum of  $5\ \text{A}$  current is (Specific resistance of the wire  $= 5 \times 10^{-7}\ \Omega\text{m}$ )
- (a) 9 (b) 6 (c) 3 (d) 1.5
6. What is the reading of voltmeter in the following figure?



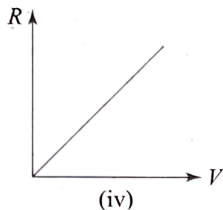
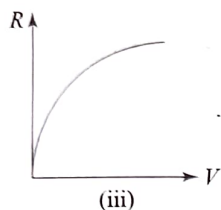
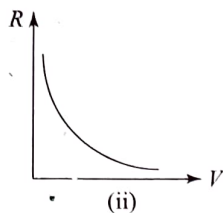
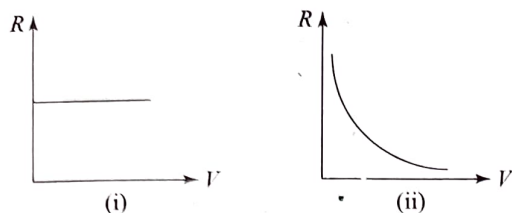
- (a) 3 V (b) 2 V (c) 5 V (d) 4 V
7. If resistance of voltmeter is  $10000\ \Omega$  and resistance of ammeter is  $2\ \Omega$ , then find  $R$  when voltmeter reads 12 V and ammeter reads  $0.1\ \text{A}$
- (a)  $118\ \Omega$  (b)  $120\ \Omega$   
(c)  $124\ \Omega$  (d)  $114\ \Omega$
8. In the circuit shown in the figure reading of voltmeter is  $V_1$  when only  $S_1$  is closed, reading of voltmeter is  $V_2$  when only  $S_2$  is closed and reading of voltmeter is  $V_3$  when both  $S_1$  and  $S_2$  are closed. Then
- (a)  $V_3 > V_2 > V_1$  (b)  $V_2 > V_1 > V_3$   
(c)  $V_3 > V_1 > V_2$  (d)  $V_1 > V_2 > V_3$



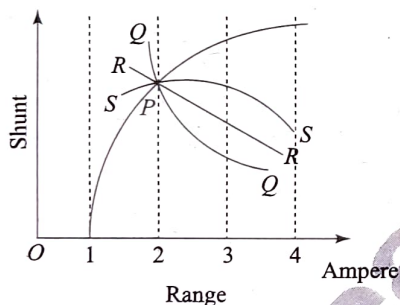
9. A moving coil galvanometer has 150 equal divisions. Its current sensitivity is 10 divisions per milliamper and voltage sensitivity is 2 divisions per millivolt. In order that each division reads 1 volt, the resistance in ohms needed to be connected in series with the coil will be
- (a) 99995 (b) 9995  
(c)  $10^3$  (d)  $10^5$



10. The graph which represents the relation between the total resistance  $R$  of a multi-range moving coil voltmeter and its full-scale deflection  $V$  is

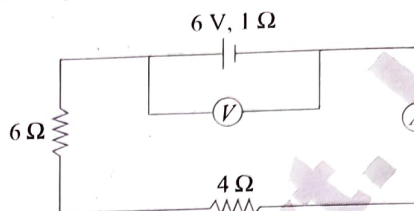


- (a) (i) (b) (ii)  
(c) (iii) (d) (iv)
11. The ammeter has range 1 ampere without shunt. The range can be varied by using different shunt resistances. The graph between shunt resistance and range will have the nature

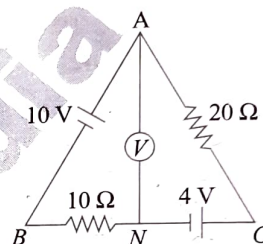


- (a) P (b) Q (c) R (d) S

12. In the circuit shown here, the readings of the ammeter and voltmeter are  
(a) 6 A, 60 V (b) 0.6 A, 6 V  
(c) 6/11 A, 60/11 V (d) 11/6 A, 11/60 V



13. The reading of the ideal voltmeter in the adjoining diagram will be  
(a) 4 V (b) 8 V  
(c) 12 V (d) 14 V



14. A moving coil galvanometer has 150 equal divisions. Its current sensitivity is 10 divisions per milliampere and voltage sensitivity is 2 divisions per millivolt. In order that each division reads 1 volt, the resistance in ohms needed to be connected in series with the coil will be  
(a) 99995 (b) 9995  
(c)  $10^3$  (d)  $10^5$

### Answers Key

#### Single Correct Answer Type

1. (d) 2. (d) 3. (c) 4. (d) 5. (c)

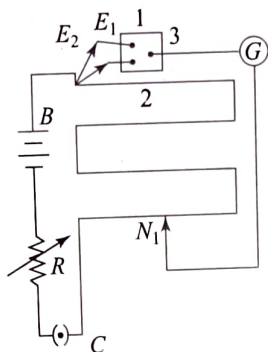
6. (d) 7. (a) 8. (b) 9. (b) 10. (d)  
11. (b) 12. (c) 13. (b) 14. (b)

# DPP 6.3

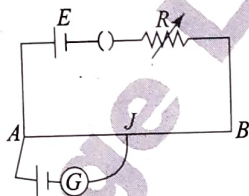
## Potentiometer

### Subjective Type

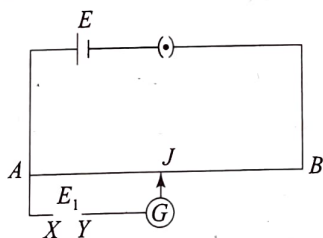
1. In an experiment with a potentiometer,  $V_B = 10$  V.  $R$  is adjusted to be  $50\ \Omega$  (see figure). A student wanting to measure voltage  $E_1$  of a battery (approx. 8 V) finds no null point possible. He then diminishes  $R$  to  $10\ \Omega$  and is able to locate the null point on the last (4th) segment of the potentiometer. Find the resistance of the potentiometer wire and potential drop per unit length across the wire in the second case.



2. What is the advantage of using thick metallic strips to join wires in a potentiometer?
3.  $AB$  is a potentiometer wire (see figure). If the value of  $R$  is increased, in which direction will the balance point  $J$  shift?



4. While doing an experiment with potentiometer (see figure) it was found that the deflection is one sided and (i) the deflection decreased while moving from one end  $A$  of the wire, to the end  $R$ ; (ii) the deflection increased, while the jockey was moved towards the end  $D$ .



- (a) Which terminal positive or negative of the cell  $E_1$  is connected at  $X$  in case (i) and how is  $E_1$  related to  $E$ ?
- (b) Which terminal of the cell  $E_1$  is connected at  $X$  in case (i) in a)?
5. A battery of e.m.f. 10 V and internal resistance  $2\ \Omega$  is connected in primary circuit with a uniform potentiometer wire and a rheostat whose resistance is fixed at  $998\ \Omega$ . A battery of unknown e.m.f. is being balanced on this potentiometer wire and balancing length is found to be 50 cm. When area of cross section of potentiometer wire is doubled, then balancing length is found to be 75 cm.
- (i) Calculate e.m.f. of the battery.
- (ii) Calculate resistivity of potentiometer wire if length of wire is 100 cm and area of cross-section (initially) is  $100\text{ cm}^2$ .

### Single Correct Answer Type

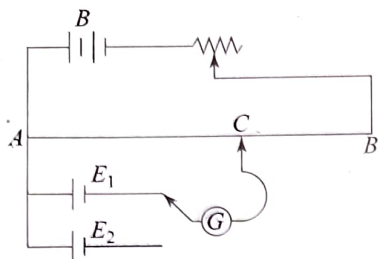
6. A potentiometer is an ideal device of measuring potential difference because
- (a) it uses a sensitive galvanometer
- (b) it does not disturb the potential difference it measures
- (c) it is an elaborate arrangement
- (d) it has a long wire hence heat developed is quickly radiated
7. A cell of internal resistance  $1.5\ \Omega$  and of e.m.f. 1.5 volt balances 500 cm on a potentiometer wire. If a wire of  $15\ \Omega$  is connected between the balance point and the cell, then the balance point will shift
- (a) To zero
- (b) By 500 cm
- (c) By 750 cm
- (d) None of the above
8. For comparing the e.m.f.s of two cells with a potentiometer, a standard cell is used to develop a potential gradient along the wires. Which of the following possibilities would make the experiment unsuccessful?
- (a) The e.m.f. of the standard cell is larger than the  $E$  e.m.f.s of the two cells
- (b) The diameter of the wires is the same and uniform throughout
- (c) The number of wires is ten
- (d) The e.m.f. of the standard cell is smaller than the e.m.f.s of the two cells
9. The circuit shown here is used to compare the e.m.f. of two cells  $E_1$  and  $E_2$  ( $E_1 > E_2$ ). The null point is at  $C$  when the



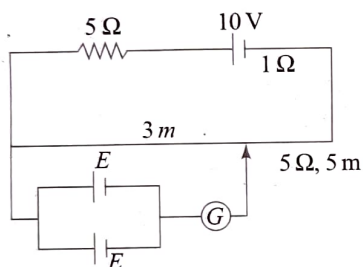
## 6.6 Electrostatics and Current Electricity

galvanometer is connected to  $E_1$ . When the galvanometer is connected to  $E_2$ , the null point will be

- (a) To the left of  $C$  (b) To the right of  $C$   
(c) At  $C$  itself (d) Nowhere on  $AB$



10. A resistance of  $4\ \Omega$  and a wire of length 5 metres and resistance  $5\ \Omega$  are joined in series and connected to a cell of e.m.f. 10 V and internal resistance  $1\ \Omega$ . A parallel combination of two identical cells is balanced across 300 cm of the wire. The e.m.f.  $E$  of each cell is  
(a) 1.5 V (b) 3.0 V (c) 0.67 V (d) 1.33 V



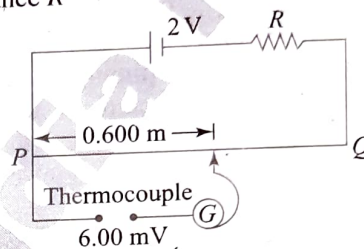
11. The length of a wire of a potentiometer is 100 cm, and the emf of its standard cell is  $E$  volt. It is employed to measure the e.m.f. of a battery whose internal resistance is  $0.5\ \Omega$ . If the balance point is obtained at  $l = 30$  cm from the positive end, the e.m.f. of the battery is

- (a)  $\frac{30E}{100}$  (b)  $\frac{30E}{100.5}$  (c)  $\frac{30E}{(100 - 0.5)}$

- (d)  $\frac{30(E - 0.5i)}{100}$

where  $i$  is the current in the potentiometer

12. Potentiometer wire of length 1 m is connected in series with  $490\ \Omega$  resistance and 2 V battery. If  $0.2\ \text{mV/cm}$  is the potential gradient, then resistance of the potentiometer wire is  
(a)  $4.9\ \Omega$  (b)  $7.9\ \Omega$  (c)  $5.9\ \Omega$  (d)  $6.9\ \Omega$   
13. Figure shows a simple potentiometer circuit for measuring a small e.m.f. produced by a thermocouple. The meter wire  $PQ$  has a resistance  $5\ \Omega$  and the driver cell has an e.m.f. of 2 V. If a balance point is obtained 0.600 m along  $PQ$  when measuring an e.m.f. of 6.00 mV, what is the value of resistance  $R$



- (a)  $995\ \Omega$  (b)  $1995\ \Omega$   
(c)  $2995\ \Omega$  (d) None of these

14. Two cells of emfs approximately 5 V and 10 V are to be accurately compared using a potentiometer of length 400 cm.

- (a) The battery that runs the potentiometer should have voltage of 8 V  
(b) The battery of potentiometer can have a voltage of 15 V and  $R$  adjusted so that the potential drop across the wire slightly exceeds 10 V  
(c) The first portion of 50 cm of wire itself should have a potential drop of 10 V  
(d) Potentiometer is usually used for comparing resistances and not voltages

## Answers Key

### Subjective Type

5. (a) 2.5 volt (b)  $10\ \Omega\text{-m}$

### Single Correct Answer Type

6. (b) 7. (d) 8. (d) 9. (a) 10. (b)  
11. (a) 12. (a) 13. (a) 14. (b)

# DPP 6.4

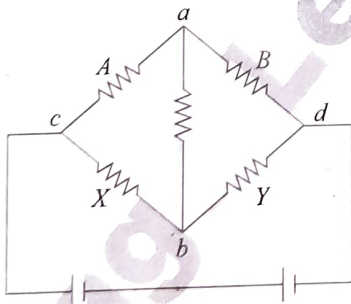
## Meter Bridge

### Subjective Type

1. What are the advantages of the null-point method in a Wheatstone bridge? What additional measurements would be required to calculate  $R_{\text{unknown}}$  by any other method?

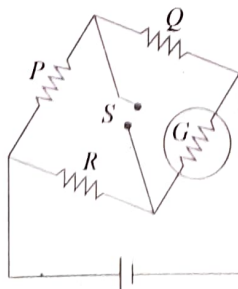
### Single Correct Answer Type

2. In meter bridge or Wheatstone bridge for measurement of resistance, the known and the unknown resistances are interchanged. The error so removed is  
 (a) end correction (b) index error  
 (c) due to temperature effect  
 (d) random error
3. In Wheatstone's bridge  $P = 9 \Omega$ ,  $Q = 11 \Omega$ ,  $R = 4 \Omega$  and  $S = 6 \Omega$ . How much resistance must be put in parallel to the resistance  $S$  to balance the bridge?  
 (a)  $24 \Omega$  (b)  $\frac{44}{9} \Omega$   
 (c)  $26.4 \Omega$  (d)  $18.7 \Omega$
4. In the Wheatstone bridge (shown in the figure)  $X = Y$  and  $A > B$ . The direction of the current between  $ab$  will be  
 (a) From  $a$  to  $b$  (b) From  $b$  to  $a$   
 (c) From  $b$  to  $a$  through  $c$  (d) From  $a$  to  $b$  through  $c$

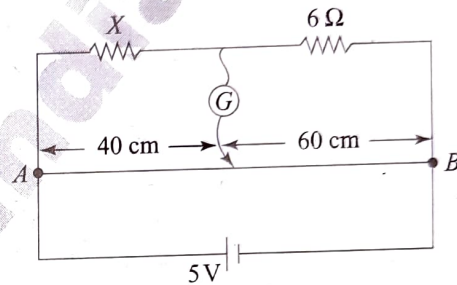


5. The figure shows a circuit diagram of a Wheatstone Bridge to measure the resistance  $G$  of the galvanometer. The relation  $\frac{P}{Q} = \frac{R}{G}$  will be satisfied only when

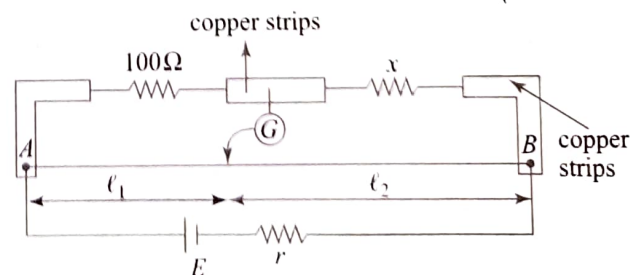
- (a) the galvanometer shows a deflection when switch  $S$  is closed  
 (b) the galvanometer shows a deflection when switch  $S$  is open



- (c) the galvanometer shows no change in deflection whether  $S$  is open or closed  
 (d) the galvanometer shows no deflection
6. In the circuit shown, a meter bridge is in its balanced state. The meter bridge wire has a resistance  $0.1 \text{ ohm/cm}$ . The value of unknown resistance  $X$  and the current drawn from the battery of negligible resistance is



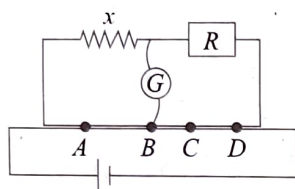
- (a)  $6 \Omega$ ,  $5 \text{ A}$  (b)  $10 \Omega$ ,  $0.1 \text{ A}$   
 (c)  $4 \Omega$ ,  $1.0 \text{ A}$  (d)  $12 \Omega$ ,  $0.5 \text{ A}$
7. In a metre bridge experiment null point is obtained at  $20 \text{ cm}$  from one end of the wire when resistance  $X$  is balanced against another resistance  $Y$ . If  $X < Y$ , then where will be the new position of the null point from the same end, if one decides to balance a resistance of  $4X$  against  $Y$   
 (a)  $50 \text{ cm}$  (b)  $80 \text{ cm}$  (c)  $40 \text{ cm}$  (d)  $70 \text{ cm}$
8. Two resistances are connected in two gaps of a metre bridge. The balance point is  $20 \text{ cm}$  from the zero end. A resistance of  $15 \text{ ohms}$  is connected in series with the smaller of the two. The null point shifts to  $40 \text{ cm}$ . The value of the smaller resistance in ohms is  
 (a)  $3$  (b)  $6$  (c)  $9$  (d)  $12$
9. In a practical wheat stone bridge circuit as shown, when one more resistance of  $100 \Omega$  is connected in parallel with unknown resistance ' $x$ ', then ratio  $l_1/l_2$  become ' $2$ '.  $l_1$  is balance length.  $AB$  is a uniform wire. Then value of ' $x$ ' must be:



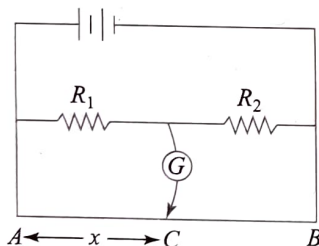
- (a)  $50 \Omega$  (b)  $100 \Omega$   
 (c)  $200 \Omega$  (d)  $400 \Omega$



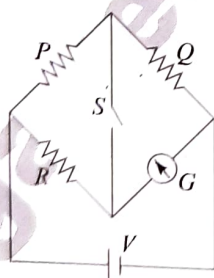
10. A resistance  $R$  is to be measured using a meter bridge, student chooses the standard resistance  $S$  to be  $100\ \Omega$ . He finds the null point at  $l_1 = 2.9\text{ cm}$ . He is told to attempt to improve the accuracy. Which of the following is a useful way?
- He should measure  $l_1$  more accurately
  - He should change  $S$  to  $1000\ \Omega$  and repeat the experiment
  - He should change  $S$  to  $3\ \Omega$  and repeat the experiment
  - He should give up hope of a more accurate measurement with a meter bridge
11.  $R_1$ ,  $R_2$  and  $R_3$  are different values of  $R$  and  $A$ ,  $B$  and  $C$  are the null points obtained corresponding to  $R_1$ ,  $R_2$  and  $R_3$  respectively. For which of the following the value of  $X$  will be the most accurate:



- A
  - B
  - C
  - D
12. In the shown arrangement of the experiment of the meter bridge if  $AC$  corresponding to null deflection of galvanometer is  $x$ , what would be its value if the radius of the wire  $AB$  is doubled
- $x$
  - $x/4$
  - $4x$
  - $2x$

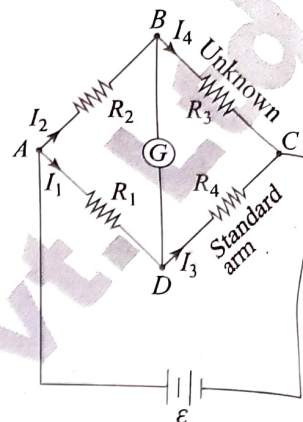


13. In the circuit shown  $P \neq R$ , the reading of the galvanometer is same with switch  $S$  open or closed. Then
- $I_R = I_G$
  - $I_P = I_G$
  - $I_Q = I_G$
  - $I_Q = I_R$



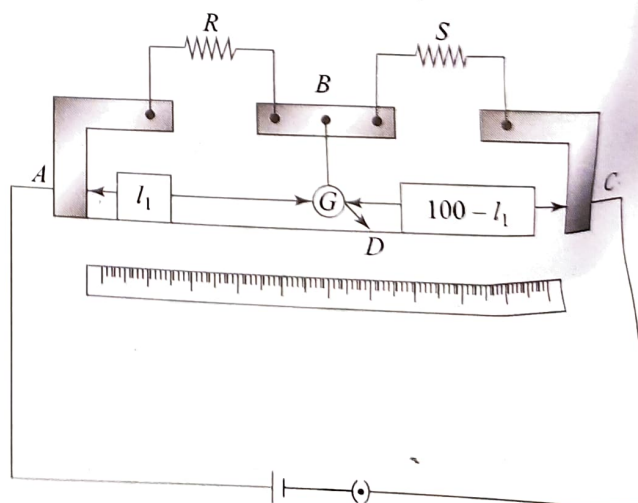
### Multiple Correct Answers Type

14. The measurement of an unknown resistance  $R$  is to be carried out using Wheatstones bridge as given in the figure. Two students perform an experiment in two ways. The first student takes  $R_2 = 10\ \Omega$  and  $R_1 = 5\ \Omega$ . The other student takes  $R_2 = 1000\ \Omega$ , and  $R_1 = 500\ \Omega$ . In the standard arm, both take  $R_3 = 5\ \Omega$ .



Both find  $R = \frac{R_2}{R_1} R_3 = 100\ \Omega$  within errors.

- The errors of measurement of the two students are the same
  - Errors of measurement do depend on the accuracy with which  $R_2$  and  $R_1$  can be measured
  - If the student uses large values of  $R_2$  and  $R_1$ , the currents through the arms will be feeble. This will make determination of null point accurately more difficult
  - Wheatstone bridge is a very accurate instrument and has no errors of measurement
15. In a meter bridge, the point  $D$  is a neutral point (see figure).
- The meter bridge can have no other neutral. A point for this set of resistances
  - When the jockey contacts a point on meter wire left of  $D$ , current flows to  $B$  from the wire
  - When the jockey contacts a point on the meter wire to the right of  $D$ , current flows from  $B$  to the wire through galvanometer
  - When  $R$  is increased, the neutral point shifts to left



### Answers Key

#### Single Correct Answer Type

- |         |         |        |         |         |
|---------|---------|--------|---------|---------|
| 2. (a)  | 3. (c)  | 4. (b) | 5. (c)  | 6. (c)  |
| 7. (a)  | 8. (c)  | 9. (b) | 10. (c) | 11. (b) |
| 12. (a) | 13. (a) |        |         |         |

#### Multiple Correct Answers Type

14. (b, c) 15. (a, c)

# Heating Effects of Current

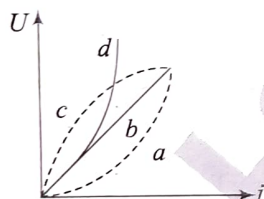
## DPP 7.1

### Calculating Thermal Power in Resistances

#### Single Correct Answer Type

1. Which of the following plots may represent the thermal energy produced in a resistor in a given time as a function of the electric current

(a) *a*      (b) *b*      (c) *c*      (d) *d*



2. Two heating coils, one of fine wire and the other of thick wire of the same material and of the same length are connected in series and in parallel. Which of the following statement is correct?

(a) In series fine wire liberates more energy while in parallel thick wire will liberate more energy  
 (b) In series fine wire liberates less energy while in parallel thick wire will liberate more energy  
 (c) Both will liberate equally  
 (d) In series the thick wire will liberate more while in parallel it will liberate less energy

3. A resistor  $R_1$  dissipates the power  $P$  when connected to a certain generator. If the resistor  $R_2$  is put in series with  $R_1$ , the power dissipated by  $R_1$

(a) decreases  
 (b) increases

(c) remains the same

(d) any of the above depending upon the relative values of  $R_1$  and  $R_2$

4. If two bulbs of wattage 25 and 100 respectively each rated at 220 volt are connected in series with the supply of 440 volt, then which bulbs will fuse

(a) 100 W bulb      (b) 25 W bulb  
 (c) None of them      (d) Both of them

5. A 100 watt bulb working on 200 volt and a 200 watt bulb working on 100 volt have

(a) resistances in the ratio of 4 : 1  
 (b) maximum current ratings in the ratio of 1 : 4  
 (c) resistances in the ratio of 2 : 1  
 (d) maximum current ratings in the ratio of 1 : 2

6. There are two electric bulbs of 40 W and 100 W. Which one will be brighter when first connected in series and then in parallel?

(a) 40 W in series and 100 W in parallel  
 (b) 100 W in series and 40 W in parallel  
 (c) 40 W both in series and parallel will be uniform  
 (d) 100 W both in series and parallel will be uniform

7. Two bulbs of 500 W and 200 W are manufactured to operate on 220 volt line. The ratio of heat produced in 500 W and 200 W, in two cases, when first they are joined in parallel and second in series, will be

(a)  $\frac{5}{2}, \frac{2}{5}$       (b)  $\frac{5}{2}, \frac{5}{2}$   
 (c)  $\frac{2}{5}, \frac{5}{2}$       (d)  $\frac{2}{5}, \frac{2}{5}$



## 7.2 Electrostatics and Current Electricity

8. Two wires 'A' and 'B' of the same material have their lengths in the ratio 1 : 2 and radii in the ratio 2 : 1. The two wires are connected in parallel across a battery. The ratio of the heat produced in 'A' to the heat produced in 'B' for the same time is  
(a) 1 : 2    (b) 2 : 1    (c) 1 : 8    (d) 8 : 1
9. Two wires A and B of the same material and mass have their lengths in the ratio 1 : 2. On connecting them to the same source, the rate of heat dissipation in B is found to be 5 W. The rate of heat dissipation in A is  
(a) 10 W    (b) 5 W  
(c) 20 W    (d) None of these
10. An electric kettle has two heating coils. When one coil is used, water in the kettle boils in 5 minutes, while when second coil is used, the same water boils in 10 minutes. If the two coils, connected in parallel are used simultaneously, the same water will boil in  
(a) 3 min 20 sec    (b) 5 min  
(c) 7 min 30 sec    (d) 2 min 30 sec
11. An electric kettle has two coils. When one of these is switched on, the water in the kettle boils in 6 minutes. When the other coil is switched on, the water boils in 3 minutes. If the two coils are connected in series, the time taken to boil the water in the kettle is  
(a) 3 minutes    (b) 6 minutes  
(c) 2 minutes    (d) 9 minutes
12. If resistance of the filament increases with temperature, what will be power dissipated in a 220 V-100 W lamp when connected to 110 V power supply  
(a) 25 W    (b) <25 W  
(c) >25 W    (d) None of these
13. Two bulbs consume same power when operated at 200 V and 300 V respectively. When these bulbs are connected in series across a D.C. source of 500 V, then  
(a) ratio of potential difference across them is 3/2  
(b) ratio of potential difference across them is 9/4  
(c) ratio of power consumed across them is 4/9  
(d) ratio of power consumed across them is 2/3

### Multiple Correct Answers Type

14. A steel wire has a resistance twice that of an aluminium wire. Both of them are connected with a constant voltage supply. More heat will be dissipated in  
(a) steel wire when both are connected in series  
(b) steel wire when both are connected in parallel  
(c) aluminium wire when both are connected in series  
(d) aluminium wire when both are connected in parallel

## Answers Key

### Single Correct Answer Type

1. (d)    2. (a)    3. (a)    4. (b)    5. (b)  
6. (a)    7. (a)    8. (d)    9. (c)    10. (a)  
11. (d)    12. (c)    13. (c)

### Multiple Correct Answers Type

14. (a, d)

# DPP 7.2

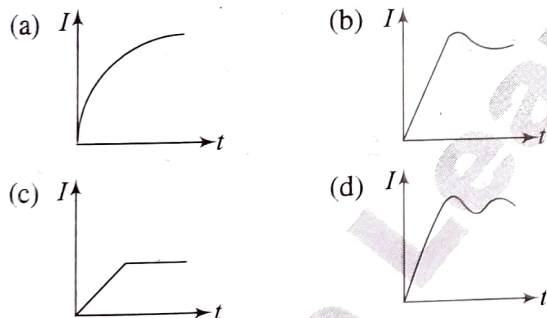
## Thermal Power in Resistances Connected in Circuits 1

### Subjective Type

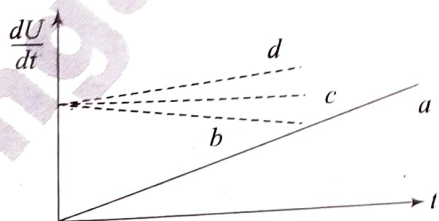
1. A room has AC run for 5 a day at a voltage of 220 V. The wiring of the room consists of Cu of 1 mm radius and a length of 10 m. Power consumption per day is 10 commercial units. What fraction of it goes in the joule heating in wires? What would happen if the wiring is made of aluminium of the same dimensions?  
 $[\rho_{\text{Cu}} = 11.7 \times 10^{-8} \Omega\text{m}, \rho_{\text{Al}} = 2.7 \times 10^{-8} \Omega\text{m}]$
2. Power  $P$  is to be delivered to a device via transmission cables having resistance  $R_c$ . If  $V$  is the voltage across  $R$  and  $I$  the current through it, find the power wasted and how can it be reduced.

### Single Correct Answer Type

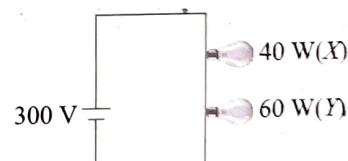
3. When an electric heater is switched on, the current flowing through it ( $i$ ) is plotted against time ( $t$ ). Taking into account the variation of resistance with temperature, which of the following best represents the resulting curve



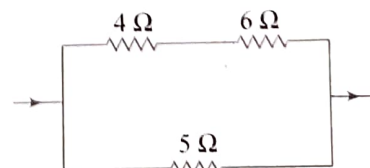
4. A constant current  $i$  is passed through a resistor. Taking the temperature coefficient of resistance into account, indicate which of the plots shown in the figure best represents the rate of production of thermal energy in the resistor  
 (a)  $a$  (b)  $b$  (c)  $c$  (d)  $d$



5. Electric bulb 50 W-100 V glowing at full power are to be used in parallel with battery 120 V,  $10 \Omega$ . Maximum number of bulbs that can be connected so that they glow in full power is  
 (a) 2 (b) 8 (c) 4 (d) 6
6. What will happen when a 40 watt, 220 volt lamp and 100 watt, 220 volt lamp are connected in series across 40 volt supply?  
 (a) 100 watt lamp will fuse  
 (b) 40 watt lamp will fuse  
 (c) Both lamps will fuse  
 (d) Neither lamp will fuse
7. Some electric bulbs are connected in series across a 220 V supply in a room. If one bulb is fused, then remaining bulbs are connected again in series across the same supply. The illumination in the room will  
 (a) increase (b) decrease  
 (c) remains the same (d) not continuous
8. Two bulbs X and Y having the same voltage rating and of power 40 W and 60 W respectively are connected in series across a potential difference of 300 V, then



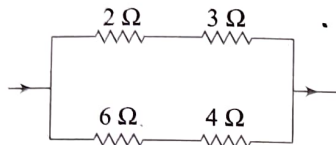
- (a) X will glow brighter  
 (b) Resistance of Y is greater than X  
 (c) Heat produced in Y will be greater than X  
 (d) Voltage drop in X will be greater than Y
9. In the circuit shown in the figure, the heat produced in 5 ohm resistance is 10 calories per second. The heat produced in 4 resistance is  
 (a) 1 cal/sec (b) 2 cal/sec  
 (c) 3 cal/sec (d) 4 cal/sec





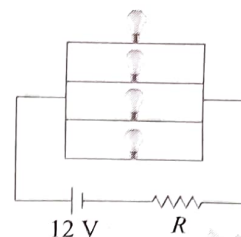
## 7.4 Electrostatics and Current Electricity

10. Water boils in an electric kettle in 15 minutes after switching on. If the length of the heating wire is decreased to  $\frac{2}{3}$  of its initial value, then the same amount of water will boil with the same supply voltage in
- (a) 15 minutes (b) 12 minutes  
(c) 10 minutes (d) 8 minutes
11. In the circuit as shown in the figure, the heat produced by 6 ohm resistance due to current flowing in it is 60 calorie per second. The heat generated across 3 ohm resistance per second will be
- (a) 30 calorie/sec (b) 60 calorie/sec  
(c) 100 calorie/sec (d) 120 calorie/sec

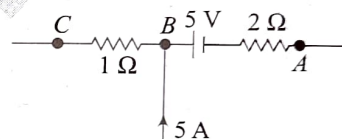


12. The resistance of a heater coil is  $110 \Omega$ . A resistance  $R$  is connected in parallel with it and the combination is joined in series with a resistance of  $11 \Omega$  to a 220 V main line. The heater operates with a power of 110 W. The value of  $R$  in ohm is
- (a) 12.22  
(b) 24.42  
(c) negative  
(d) that the given values are not correct
13. Four identical electrical lamps are labelled 1.5 V, 0.5 A, which describes the condition necessary for them to operate

at normal brightness. A 12 V battery of negligible internal resistance is connected to lamps as shown, then



- (a) The value of  $R$  for normal brightness of each lamp is  $(3/4) \Omega$   
(b) The value of  $R$  for normal brightness of each lamp is  $(21/4) \Omega$   
(c) Total power dissipated in circuit when all lamps are normally bright is 24 W  
(d) Power dissipated in  $R$  is 21 W when all lamps are normally bright
14. If the cell of emf 5 volt shown in the figure gives a power of 10 W, find the powers consumed by the resistors  $2 \Omega$  and  $1 \Omega$



- (a) 2 W, 18 W (b) 8 W, 49 W  
(c) 8 W, 18 W (d) 2 W, 49 W

## Answers Key

### Single Correct Answer Type

3. (b) 4. (d) 5. (c) 6. (d) 7. (a)

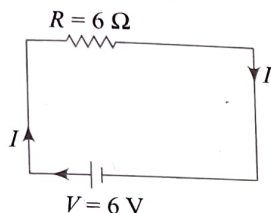
8. (a) 9. (b) 10. (c) 11. (d) 12. (a)  
13. (b) 14. (b)

# DPP 7.3

## Thermal Power in Resistances Connected in Circuits 2

### Subjective Type

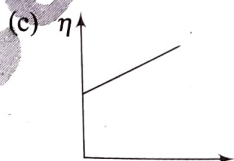
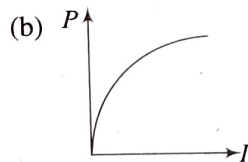
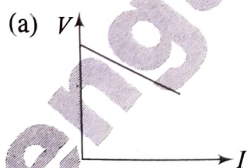
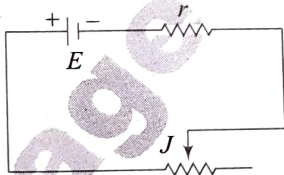
1. Consider the circuit in the figure.



- How much energy is absorbed by electrons from the initial state of no current (Ignore thermal motion) to the state of drift velocity?
- Electrons give up energy at the rate of  $RI^2$  per second to the thermal energy. What time scale would the number associate with energy in problem (a)?  $n$  = number of electron/volume =  $10^{29}/\text{m}^3$ . Length of circuit = 10 cm cross-section =  $A = (1 \text{ mm})^2$ .

### Single Correct Answer Type

2. Battery shown in the figure has e.m.f.  $E$  and internal resistance  $r$ . Current in the circuit can be varied by sliding the contact  $J$ . If at any instant current flowing through the circuit is  $I$ , potential difference between terminals of the cell is  $V$ , thermal power generated in the cell is equal to  $\eta$  fraction of total electrical power generated in it, then which of the following graph is correct



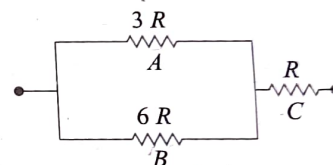
(d) Both (a) and (b) are correct

3. Two identical electric lamps marked 500 W, 220 V are connected in series and then joined to a 110 V line. The power consumed by each lamp is

- $\frac{125}{4}$  W
- $\frac{25}{4}$  W
- $\frac{225}{4}$  W
- 125 W

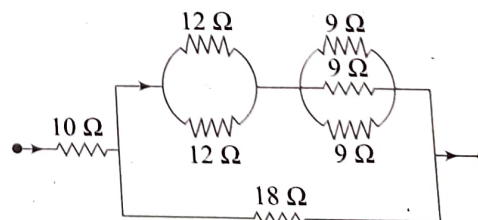
4. The three resistances  $A$ ,  $B$  and  $C$  have values  $3R$ ,  $6R$  and  $R$  respectively. When some potential difference is applied across the network, the thermal powers dissipated by  $A$ ,  $B$  and  $C$  are in the ratio

- 2 : 3 : 4
- 2 : 4 : 3
- 4 : 2 : 3
- 3 : 2 : 4



5. If the length of the filament of a heater is reduced by 10%, the power of the heater will
- increase by about 9%
  - increase by about 11%
  - increase by about 19%
  - decrease by about 10%
6. The resistance of the filament of a lamp increases with the increase in temperature. A lamp rated 100 W, 220 V is connected across 220 V power supply. If the voltage drops by 10%, then the power of lamp will be
- 90 W
  - 81 W
  - Between 90 W and 100 W
  - Between 81 W and 90 W
7. In the following circuit,  $18 \Omega$  resistor develops 2 J/sec due to current flowing through it. The power developed across  $10 \Omega$  resistance is

- 125 W
- 10 W
- $\frac{4}{5}$  W
- 25 W





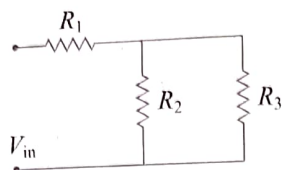
## 7.6 Electrostatics and Current Electricity

8. For ensuring dissipation of the same energy in all three resistors ( $R_1$ ,  $R_2$ ,  $R_3$ ) connected as shown in the figure, their values must be related as

- (a)  $R_1 = R_2 = R_3$   
 (b)  $R_2 = R_3$  and  $R_1 = 4R_2$

- (c)  $R_2 = R_3$  and  $R_1 = \frac{1}{4}R_2$

- (d)  $R_1 = R_2 + R_3$



9. The resistance of the filament of an electric bulb changes with temperature. If an electric bulb rated 220 V and 100 W is connected ( $220 \times .8$ ) V sources, then the actual power would be

- (a)  $100 \times 0.8$  W  
 (b)  $100 \times (0.8)^2$  W  
 (c) Between  $100 \times 0.8$  W and 100 W  
 (d) Between  $100 \times (0.8)^2$  W and  $100 \times 0.8$  W

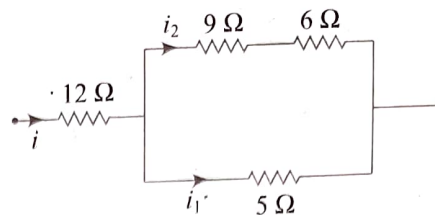
10. An electric bulb rated for 500 W at 100 V is used in a circuit having a 200-V supply. The resistance  $R$  that must be put in series with the bulb, so that the bulb draws 500 W is

- (a) 10  $\Omega$  (b) 20  $\Omega$  (c) 50  $\Omega$  (d) 100  $\Omega$

11. The wiring of a house has resistance 6  $\Omega$ . A 100 W bulb is glowing. If a geyser of 1000 W is switched on, the change in potential drop across the bulb is nearly

- (a) Nil (b) 23 V (c) 32 V (d) 12 V

12. In the following circuit, 5  $\Omega$  resistor develops 45 J/s due to current flowing through it. The power developed per second across 12  $\Omega$  resistor is



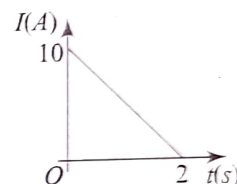
- (a) 16 W (b) 192 W (c) 36 W (d) 64 W

### Multiple Correct Answers Type

13. Consider a resistor of uniform cross section area connected to a battery of internal resistance zero. If the length of the resistor is doubled by stretching it, then

- (a) current will become four times.  
 (b) the electric field in the wire will become half.  
 (c) the thermal power produced by the resistor will become one-fourth.  
 (d) the product of the current density and conductance will become half.

14. A variable current flows through a 1  $\Omega$  resistor for 2 seconds. Time dependence of the current is shown in the graph.



- (a) Total charge flown through the resistor is 10 C.  
 (b) Average current through the resistor is 5 A.  
 (c) Total heat produced in the resistor is 50 J.  
 (d) Maximum power during the flow of current is 100 W.

## Answers Key

### Single Correct Answer Type

2. (d) 3. (a) 4. (c) 5. (b) 6. (d)  
 7. (b) 8. (c) 9. (d) 10. (b) 11. (b)  
 12. (b)

### Multiple Correct Answers Type

13. (b, c) 14. (a, b, d)